THE OCEAN SALMON TROLL FISHERY OF OREGON

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INTRODUCTION

History of the Fishery

After it was found in the early nineteen hundreds that the chinook, king or spring salmon (*Oncorhynchus tschawytscha*) and the silver or coho salmon (*O. kisutch*) could be taken in the ocean by trolling, the fishery spread rapidly along the Pacific Coast.

The first commercial trolling in the Columbia River area was started about 1912 by men who were actively engaged in gill net fishing. They found that at certain times they could catch more salmon by trolling than by netting; thus they would often gill net at night and troll during the day. During the next few years after 1915 there was a rapid development of the fishery due to the influence of World War I, and by 1919 an estimated one to two thousand boats were fishing off the mouth of the Columbia River (Smith, 1920 and Cobb, 1921). These were small boats using comparatively inefficient gear. Since then there has been a decrease in the number of boats fishing but a great increase in their efficiency.

In the early 1920's it was found that the salmon could be caught more easily on the feeding banks than when concentrated off the mouths of the rivers. The fishery then began to change from the small day boat type into its present form, consisting of large ocean-going vessels capable of remaining on the fishing grounds for a week or more. There are still large numbers of small boats, however, which fish around the mouths of the rivers, returning to port each day to sell their catch. These are augmented by many gill net and crab boats which turn to salmon trolling during the height of the troll season. As the fishermen built better boats and gear, more waters were explored, and the Newport and Coos Bay areas became important as troll fishery centers also.

The rapid development of the albacore fishery after 1936 resulted in a significant change in salmon trolling. The large trollers were ideally suited for tuna, and they began to fish for them during July, August and September. These large trollers then did most of their salmon fishing during April, May and June. Thus the height of the fishery has tended to shift from the late summer when the fish are concentrated off the rivers to earlier in the summer when the fish are still on the feeding banks. Many trollers stay with salmon throughout the season, and, especially during a poor tuna year, many fishermen will return to salmon fishing after a few unsuccessful attempts at albacore. The profitable tuna fishery combined with high prices for fish during and after World War II were instrumental in allowing many of the troll fishermen to secure bigger and better boats.

Although it is extremely difficult to obtain a count of boats engaged in the Oregon troll fishery (due to the mobility of the fleet and the fact that trollers which fish beyond the three mile limit are not required to secure troll licenses), there are an estimated 500 boats which make Oregon ports their base of operations. Likewise, it is difficult to make a statement as to how much the fishing intensity has changed. The number of boats has probably decreased from the earlier years, but there has been a great increase in their size and efficiency. The advent of the tuna fishery has also had an important, but unmeasured effect. While these Oregon boats fish mainly off the Oregon coast, they will follow runs of salmon from Eureka, California, to Vancouver Island. Similarly, when salmon are reported off the Oregon coast, trollers from California and various Washington ports, as well as the Oregon trollers, fish in that area.

There have been several excellent descriptions of the gear used for trolling in other areas of the Pacific Coast, and the gear used in Oregon does not differ in any great respect. Smith (1920), Cobb (1921) and Scofield (1921) explain the gear used in the early days of the fishery, while Chapman, Smith and Ellis (1936) describe the recent types of trolling gear and its usage. An excellent description of the trolling gear is also contained in Fish Bulletin 74 of the Bureau of Marine Fisheries, California Division of Fish and Game.

The average Oregon landings from 1940 through 1947 were about 1,500,000 pounds of each species, chinook and silver. The peak of the silver salmon fishery was reached in 1935 when over

6,000,000 pounds were landed; the catch has declined steadily since this date. The chinook landings have shown a slight tendency for an upward trend to a peak in 1947 of about two and one-half million pounds (Fig. 1).

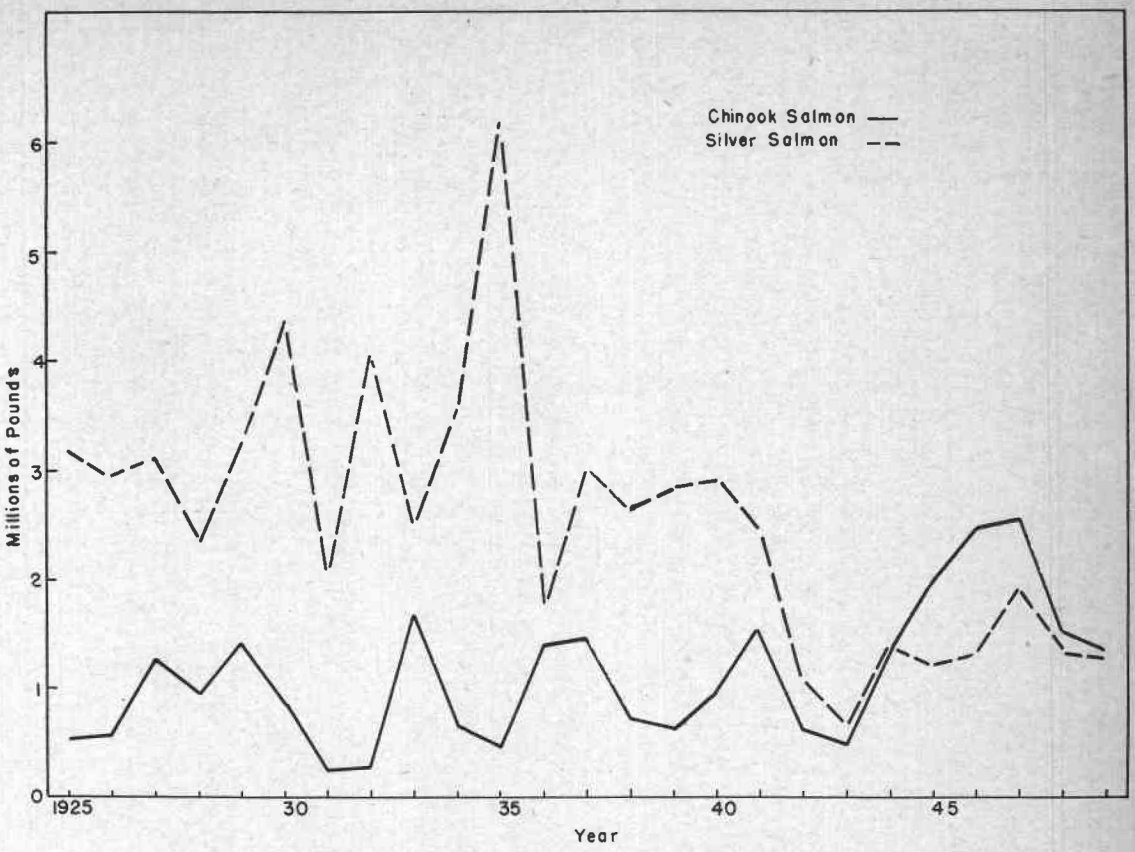

FIGURE 1. Landings of Troll-Caught Chinook and Silver Salmon in Oregon.

Except for occasional size limits this fishery has been practically unregulated since its inception. Beginning in 1948, regulations were imposed based largely on data secured the previous season. The regulations consisted of a 27-inch (total length) size limit on chinooks and an open season from July 1 to November 15 for silvers. To conform with the other Pacific Coast states these regulations were changed in 1949 to include a 26-inch minimum size limit and an open season from March 15 to November 1 on chinooks, and an open season on silvers from June 15 to November 1 with no size limit. These regulations are of a preliminary nature and further research will undoubtedly indicate necessary changes.

History of the Research

Considering the importance of the troll fishery, both in its direct economic value and its possible effect upon the other salmon fisheries, it is surprising what little research has been accomplished.

Smith (1920) discussed the troll fishery of Washington and the Columbia River, with particular respect to the numbers of small immature salmon taken. He compared the average sizes of salmon caught by the troll and purse seine fleets in offshore waters with those taken by gill nets, traps and seines and concluded that the taking of immature salmon was responsible for a great waste of valuable food fish. Not only was the loss great, but much of the ocean-caught salmon was of a poor quality. He also gave some figures on the growth of silver salmon.

Rich (1925) analyzed the growth and degree of maturity of chinook salmon taken off the mouth of the Columbia River and compared the age composition of the ocean catch with that of the river catch. Fish in their fourth and fifth years were found to be most numerous in the river catches,

while in the ocean catches, fish in their third and fourth years were most numerous. The percentage of immature fish in the ocean catch varied during the season from about 80 percent in May to around 10 percent during August. Rich pointed out many of the undesirable features of ocean fishing which he insisted was especially destructive during the spring and early summer.

Spring salmon, i.e. chinooks, were tagged from 1925 to 1930 in Canadian waters, Clemens (1932), Pritchard (1934), Williamson (1927 and 1929), and Williamson and Clemens (1932). These experiments are of great interest to Oregon as they showed for the first time how chinook salmon from the Columbia and other coastal rivers migrated along the coast. A very high percentage of the tag returns from these experiments came from the Columbia River, which indicated that trollers from the Columbia River to northern British Columbia and possibly Alaska, were fishing on stocks of Columbia River salmon.

Chapman, Smith and Ellis (1936) discussed the Washington troll fishery in general, with emphasis on catch statistics, and they also gave some data on growth and food habits.

Preliminary observations on the Oregon troll fishery were made at Reedsport during the summer of 1946 by the staff of the Oregon Fish Commission. These studies led to the instigation of a more intensive research program during 1947 to learn the age composition, growth, migrations, length-weight relationship, and seasonal and area variations in size and abundance of the troll-caught fish. Further impetus to the research program was provided by the formation of the Pacific Marine Fisheries Commission in 1947. Ocean tagging as well as a more intensive sampling program was started in 1948. Observers were stationed at Astoria, Newport, and Coos Bay from June through September. In subsequent years samples have been obtained through the entire trolling season from March to November.

Much of the material presented in this paper is of a preliminary nature, and a large quantity of sampling and biological data awaits more detailed analyses before presentation.

Fishing Areas

The trolling waters of Oregon may be divided into three general areas; Columbia River (Astoria), Newport, and Coos Bay. Various figures show the distinguishing features of the Oregon coast. Refer for example to Figures 4 and 5 (shown on pages 54 and 55).

The Columbia River fishing area extends from Willapa Bay to Cape Lookout. The major ports are Astoria, Oregon and Ilwaco, Washington, with smaller landings being made at Warrenton and Tillamook, Oregon and Chinook, Washington. Astoria was formerly the principal port, but with the improvement of channel and harbor facilities, Ilwaco has become increasingly important. The boats from the two ports fish the same area, and many of the salmon landed at Ilwaco are brought to Astoria for canning and packing.

In this case the port where the fish are landed depends on economic factors, mainly the price, and not biological factors. Therefore, troll landings on the Oregon and Washington side of the Columbia River have been combined in many of the discussions to follow. The Columbia River and Grays Harbor fleets often intermingle on the fishing grounds, but the amount of fish caught off the Columbia River and landed in Grays Harbor is rather inconsequential. Likewise, the amount of fish caught off Grays Harbor and landed in Astoria is of minor importance compared with the landings of fish caught off the mouth of the river. Most of the fishery takes place directly off the mouth of the Columbia River, but many boats also fish north and south of the river and deliver their fish to Columbia River ports.

In March and April the spring chinook run appears off the river, and if the weather is good, large catches are made. During May, June and July small immature salmon are found feeding off the river and most of the larger boats deploy to other areas. Many go to Grays Harbor or farther north and some as far south as California. Many salmon taken off Grays Harbor are landed at Astoria during this time. In July many of the boats turn to tuna fishing, leaving a reduced but still impressive fleet of smaller boats fishing for salmon. During July silvers usually are taken in large numbers, and in August the big fall chinook run appears off the Columbia River. Good catches of both species are made during August, but after the fall run leaves the ocean in early September there

are few chinooks to be found. The fishing after that time is almost exclusively for silvers. Some trolling takes place in the lower part of the Columbia River up as far as Astoria when the chinooks move into the river. Bad weather and lack of fish in October or November usually bring activities to a halt.

The Newport area extends roughly from Cape Lookout on the north to Heceta Head on the south. Most of the fish caught in this area are landed at Newport or Depoe Bay. This area includes the well-known fishing area, Stonewall Bank, commonly called the "Rock Pile." Intensive chinook fisheries take place on this bank, as well as at Heceta Bank and off Heceta Head, Cape Perpetua, and Cascade Head.

Occasional salmon landings are made in the Newport area during the spring months, but for the most part the fishery begins in June with large chinooks appearing on the "Rock Pile." These are later replaced by smaller chinooks and silvers. When the silvers appear they are taken throughout the entire area with concentrations off the mouths of the rivers later in the summer. This area also has a major ocean sport fishery which will be discussed in another section.

The third area is in the vicinity of Coos Bay and extends from Heceta Head to the California border. This includes a large expanse of coastline, but most of the fishery takes place between the Coquille River and Heceta Head. The principal ports are in Coos Bay, but large landings are also made at Winchester Bay and Reedsport on the Umpqua River and smaller landings at Port Orford, Bandon on the Coquille River, and Florence on the Siuslaw River. Port Orford boats and some from Coos Bay fish the area south of Cape Blanco, but much of this area, including the Rogue River, is fished by California boats. (Fig. 2.) The Port Orford troll fleet is an interesting one consisting of about 20 small boats which are kept on a dock extending out into the open ocean. At the beginning of each day's fishing the boats are wheeled on trailers to a crane which lowers them into the water and at the end of the day they are hoisted up again. Very little fishing takes place in the spring in this area due to absence of salmon. The fishery starts in June with the appearance of both chinook and silver salmon scattered throughout the area. The chinooks seem to be mostly immature feeding fish and average somewhat smaller in size than in the other areas.

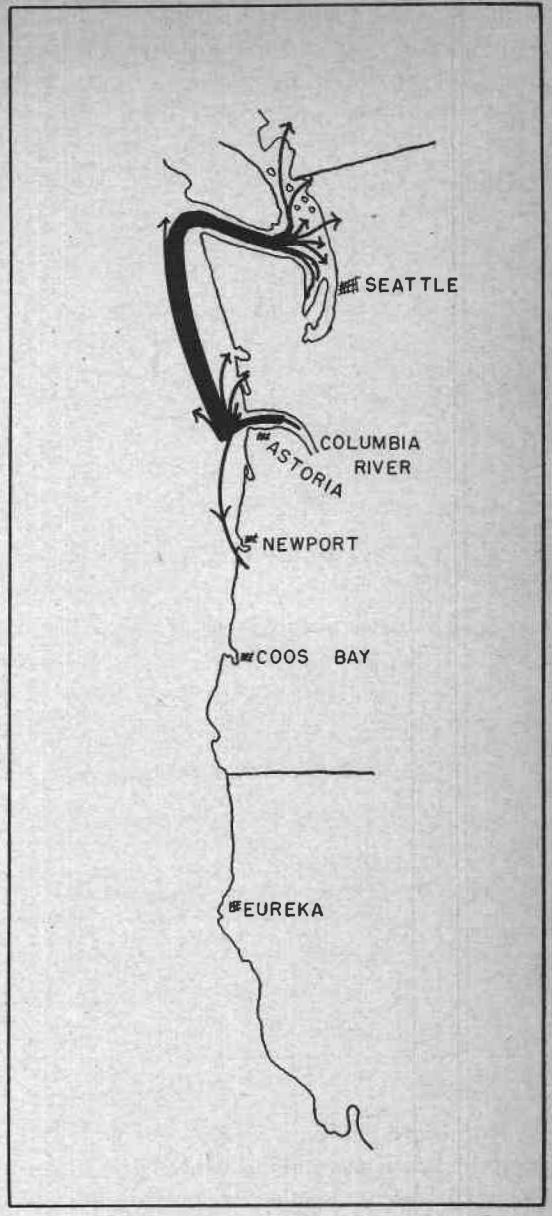

FIGURE 2. Migration of Silver Salmon Tagged between the Columbia River and Cape Lookout, Oregon, in 1948 and 1949.

THE SILVER SALMON FISHERY

Migration

TAGGING EXPERIMENTS

The first attempt to learn the migratory habits of salmon found off the Oregon Coast was in 1926. At the suggestion of the International Pacific Salmon Federation and Dr. Willis H. Rich,

an attempt was made to tag silver and chinook salmon in the ocean. A fisheries patrol boat, equipped with trolling gear and manned by two wardens, was first used. After several days of fishing in early August, this boat was found unsatisfactory for the work. Arrangements were then made to accompany the troller "Mabel" of Hoquiam with Mr. Matt Walteri as captain. A trip was made down the coast from Astoria to Port Orford during August and September. A total of 224 silver salmon and 135 chinook salmon were tagged during the season. Apparently little effort was expended in the recovery of the tags, and the records show only three silvers and two chinook tags recovered.

The silver salmon recoveries were as follows:

1. Tagged August 2, 1926, off Tillamook Head.
   Recovered August 21, 1926, in a trap in the Columbia River.
2. Tagged August 16, 1926, six miles south of the Columbia River.
   Recovered August 23, 1926, in the Columbia River.
3. Tagged September 13, 1926, off Cape Blanco.
   Recovered October 28, 1926, in the Nehalem River.

Additional tagging was attempted during August and September of 1927, during which time 200 silvers and 5 chinooks were tagged. Available records do not state how they were tagged or if any were recovered.

In 1948 and 1949 at the suggestion of the Pacific Marine Fisheries Commission, salmon were, again tagged in the ocean. Tables 1 and 2 summarize the tagging and recoveries. The salmon were caught from commercial trollers and tagged with Peterson-type celluloid disc tags attached below the dorsal fin. The tag number, date, and area of release were noted, and also the condition, where hooked, and fork length were taken at the time of tagging.

TABLE 1.—TROLL SILVER SALMON TAGGING, OREGON*

Area	1948			1949			Total		
	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered
Columbia River	190	16	8.4	32	3	9.4	222	19	8.6
Newport	27	2	7.4	193	7	3.6	220	9	4.1
Coos Bay	32	1	3.1	32	0	0.0	64	1	1.6
Total	249	19	7.6	257	10	3.9	506	29	5.7

* These data do not include fish tagged in 1948 and 1949 that were recovered in 1950 and later.

No reward was paid for the return of the tags, but an intensive campaign to secure cooperation from the fishermen and dealers was instigated in its stead. Also large numbers of both troll and river caught fish were sampled in order to determine the ratio of tagged fish in the catch.

Tagging of Silvers in the Columbia River or Northern Area of Oregon

The troll silver season opened on July 1, in 1948, so it was possible to secure fish at a very reasonable cost before that date. Large numbers of silvers were reported early in the season, and a troller was chartered for eight days during the latter part of June to tag some of these fish. A large school of silvers was encountered in the area between Tillamook Bay and Cape Lookout and 190 of them were tagged. A recovery of 16 or 8.4 percent was obtained from this experiment (Table 1). It is interesting to note how the fish tagged at the same time and apparently from the same school scattered out to their respective recovery areas. Puget Sound contributed the greatest number of returns (seven fish or 43.8 percent) from this particular group of fish, while three (18.8 percent) were found in the Columbia River, three (18.8 percent)were taken by trollers between the mouth of the Columbia River and Grays Harbor, one (6.2 percent) was returned from Willapa Bay, one (6.2 percent) went south to the Alsea River, and for one the recovery area was not known. The results show that this school of fish had individuals bound chiefly for the Puget Sound area, and also contained some bound for the Columbia and coastal rivers as well. The exact contribution made by runs from the areas of recovery will vary with the fishing intensity in the various recovery areas.

In 1949 no silvers were present in the vicinity of the Columbia River early in the season, so the tagging was limited to accompanying the trollers and buying fish from them. Due to an extremely poor silver year, only 32 silvers were tagged in this manner. There were three recoveries, one in the Fraser River, one at Whidby Island (Puget Sound), and one was taken off the Columbia River 50 days later.

In summary, 222 silvers were tagged in the northern Oregon area in 1948 and 1949 and 19 were recovered. Figure 2 shows a map of the migration routes. Of the 19 recoveries, 47.4 percent were recovered in the Puget Sound area, 5.3 percent in the Washington coastal streams, 21.0 percent off the Columbia River and Washington coast, 15.8 percent in the Columbia River, 5.3 percent in the Oregon coastal streams, and as previously mentioned, one fish was returned with no information as to locality of recovery. It must be remembered that nearly all of this tagging was done during June and July; if more had been tagged later in the season, there undoubtedly would have been more recoveries from the Columbia River and southern areas. It is interesting to note that two silvers tagged in 1948 were recovered in 1949 (Table 2). Recoveries in 1950 are not included.

TABLE 2. TROLL SILVER SALMON TAG RECOVERIES, OREGON TAGGING
(Tagged in 1948–49, Recovered in 1948–49)

TAGGED			RECOVERED				
Tag No.	Date	Location	Date	Location	Days Out	Migration	Gear
A-423	19 June 1948	Cape Lookout	2 Oct. 1948	Hoods Canal	105	300 N.	Sport
429	do.	do.	13 Sept. 1948	Whidby Island	86	310 N.	Sport
444	do.	do.	28 Oct. 1948	Willapa Bay-Nemah R.	131	100 N.	?
468	do.	do.	1 Oct. 1948	Hoods Canal	104	300 N.	Sport
426	do.	do.	Aug.-Sept. 1949	Cape Flattery to Swiftsure	450 ±	200 N. ±	Purse seine
432	do.	do.	8 Dec. 1948	Col. R. at Cathlamet	172	95 N.	Gill net
447	do.	do.	15–21 Aug. 1948	Off North Head	60 ±	65 N.	Troll
443	do.	do.	24 Aug. 1948	Skagit R.	66	285 N.	Gill net
493	do.	do.	16 Sept. 1948	Nooksac R.	89	320 N.	?
474	do.	do.	7 Oct. 1948	Alsea R.	110	55 S.	Gill net
484	do.	do.	15–21 Aug. 1948	?	60 ±	?	?
525	22 June 1948	do.	19 Sept. 1948	Off Grays Harbor	89	85 N.	Troll
502	do.	do.	10 Sept. 1948	Off Columbia R.	80	45 N.	Troll
564	do.	do.	29 Sept. 1948	Lopez Island	99	270 N.	Purse seine
540	do.	do.	28 Nov. 1948	Lower Columbia R.	160	85 N.	?
513	do.	do.	Oct. 1949	Columbia R.	500 ±	100 N. ±	?
C-703	24 June 1949	Off Col. R.	6 Sept. 1949	Fraser R.	74	280 N.	Gill net
738	13 July 1949	Off Col. R.	1 Sept. 1949	Off Columbia R.	50	0	Troll
762	22 July 1949	Off Col. R.	17 Aug. 1949	Whidby Island	26	240 N.	Purse seine
24	22 June 1948	Off Newport	10 Sept. 1948	Off Columbia R.	80	85 N.	Troll
34	do.	do.	25 Aug. 1948	Off Willapa Bay	64	120 N.	Troll
98	4 Aug. 1949	Off Depoe Bay	22 Sept. 1949	Sooke, B. C.	49	270 N.	Trap
106	4 Aug. 1949	do.	1 Oct. 1949	Kalama R., Wash.	57	160 N.	Hatchery
124	5 Aug. 1949	do.	28 Aug. 1949	Off Umpqua R.	23	70 S.	Sport
136	6 Aug. 1949	do.	19 Aug. 1949	Off Newport	13	20 S.	Troll
199	19 Aug. 1949	do.	10 Sept. 1949	Lower Columbia R.	22	90 N.	?
250	27 Aug. 1949	do.	18 Oct. 1949	Naselle R., Wash.	52	130 N.	?
246	28 Aug. 1949	do.	22 Sept. 1949	Tillamook R.	26	55 N.	Gill net
R-100	17 June 1948	Off Coos Bay	28 Oct. 1948	Lower Columbia R.	133	195 N.	?

Tagging of Silvers in the Coastal Area South of the Columbia River

In 1948 tagging along the coast was confined to silvers obtained from the trollers before the season opened. Twenty-seven were tagged off Newport and 32 off Coos Bay. Two tagged off Newport were caught by trollers between Willapa Bay and the Columbia River, and one from the Coos Bay tagging was recovered in the Columbia River.

In 1949 a small boat was chartered during June, July and August to tag salmon out of Depoe Bay and Newport. Due to an extreme lack of fish and poorer than usual weather, only 193 silvers were tagged. Recoveries from this experiment were very few, only seven being recovered. One was taken in a trap at Sooke, Vancouver Island, one in a Washington stream, two in the Columbia

River, one in an Oregon coastal stream (Tillamook River), and two by trollers off the Oregon coast (Table 2). Thirty-two silvers were tagged off Coos Bay in 1949, but there were no recoveries.

Figure 3 shows the migration routes of silvers released in the coastal area. A summary of the ten returns from the coastal tagging shows a ten percent recovery from Puget Sound, ten percent from Washington coastal streams, 40 percent by trollers off the Washington and Oregon coasts, 30 percent from the Columbia River and ten percent from the Oregon coastal streams. It appears that the Puget Sound's influence becomes less as one proceeds southward, while the Columbia River's influence becomes more dominant along the Oregon coast. However, as mentioned before, the tagging did not all take place at the same time which could change the conclusion somewhat.

The predominant northward movement of silvers from the point of tagging is obvious. This is the reversal of what Mottley (1929) and Pritchard (1934) found for silver and spring salmon tagged off British Columbia, but the results can perhaps be interpreted in much the same manner, only with a northward instead of a southward migration back to their home streams.

The young silvers enter the ocean during the spring of their second year and apparently turn south on a "feeding" or "dispersal" migration. They feed and move south during that summer and the following winter. The spring of their third year finds them a considerable distance south of their point of origin. Perhaps their approaching maturity is the factor which stops them in their southward migration and turns them north to make a rapid migration back to their parent streams. The young silvers which leave the northern streams will probably not travel as far south on their "feeding" migration as those from the more southern streams before they turn back to their spawning areas. Pritchard (1934 and 1940) found that the chinooks from the larger rivers dominate the catch in certain areas, and he suggested that each large chinook river has a "sphere of influence." For example the Columbia River fish dominate the catch as far north as the west coast of the Queen Charlotte Islands. This cannot be shown as clearly for silvers since they spawn in nearly every stream along the coast, but if they are grouped into larger areas, a similar situation is suggested, in that silvers originating from a certain area dominate the catch at certain times. That some silvers make a northward feeding migration and a southward spawning migration is demonstrated by one silver tagged at Sooke, B. C., and recovered in the Columbia River.

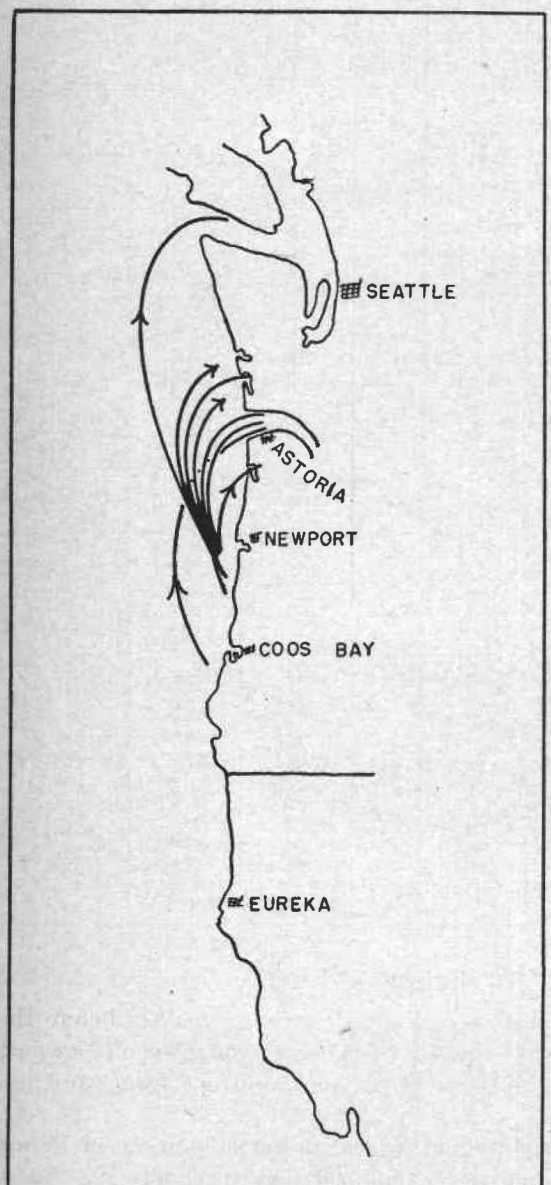

FIGURE 3. Migration of Silver Salmon Tagged Off the Coastal Areas of Oregon in 1948 and 1949.

The rate of ocean migration for those silvers tagged and recaptured is calculated to be 1.6 miles a day, with a range of from 0 to 9.2 miles a day. Only the recoveries which were made in salt water were used in calculating this rate, since in the case of most river recoveries, the distance up the river was not given, and in no cases would it be possible to tell how long the fish had been in the stream. It is interesting to note the decrease in percent recovered from north to south (Table 1), possibly indicating a decrease in fishing intensity from the northern areas to the southern areas.

This preliminary tagging does not show the exact contribution of the various rivers to the troll catch, but it does give a general picture of silver salmon migration along the coast. More tagging, especially during the height of the troll season, will give a better understanding of the migration patterns and the contributions of the various areas to the troll catch.

Marking Experiments

In view of the proposed program to mark (fin clip) large numbers of small salmon at the hatcheries and study their subsequent recovery in the ocean, it would be of value to point out what has been learned of ocean migrations from previous marking experiments. These experiments were designed to investigate various phases of the salmon's fresh water life, but something of their ocean life may also be determined. The numbers of ocean returns will of course be subject to the various types of treatment the fish received during their early life history, plus varying intensities of fishing and recovering the marked fish.

Two extensive experiments were undertaken by the Oregon Fish Commission with silvers of the 1944 brood year to determine the best time to release hatchery-reared silver salmon. There were 100,061 silvers released at the Bonneville Hatchery on the Columbia River and 99,436 were released in the Alsea River, a central Oregon coastal stream. The recoveries were made in 1947, by offering a $0.50 reward for the mark and also by sampling the catch. Most of the returns were obtained through the reward system by the cannery workers, and in those cases the exact locality of the catch cannot be determined, but they have been grouped by the ports at which they were landed. This gives a rough approximation of their distribution along the coast. Unfortunately no record was kept of the locality of capture of the marked fish which were recovered in the sampling.

The ocean recoveries of the Alsea River marked silver salmon are shown in Figure 4. In general they confirm the tagging, in that early in the season most of the silvers were found south of their home streams, with a scattering to the north. Large numbers of them were recovered off Coos Bay in June and July. During August they left the southern coastal areas and began to gather around the Alsea River, and during September and October, as one would expect, they were mostly gathered off the mouth of the Alsea with some possibly still left to the north. The apparent presence of numbers of them off the Columbia River might be explained by the fact that, although they were landed at Astoria, they could have come from boats that had been fishing off Newport and the Alsea River. Although no effort was made to recover these marks in other states, at least two were found off Eureka and Crescent City in June and one was reported off the northern tip of Vancouver Island.

Figure 5 shows the ocean recoveries of the Bonneville Hatchery marking of 1944 brood year silver salmon fingerling. Again is noted the southerly distribution early in the season, becoming more northerly as the season advanced. Relatively few of these fish were taken off Coos Bay, compared with large numbers of the Alsea River fish. It is not known if there were any of these fish taken off the Washington or California coast.

As mentioned before, this gives a very general idea of the migration pattern and is in no sense as precise as tagging, but coupled with a tagging program, the marked fish returns give a clearer picture of the ocean habits of silver salmon. The numbers of marks returned from the various areas depend upon the intensity of the fishery as well as upon the intensity of effort in recovering the marks. This can be overcome by sampling a portion of the catch in the different areas on a coastwise basis and correcting the recoveries by the catch by areas.

This seems to be the only marking experiment where an intensive campaign to secure marks from the ocean fishery has been carried out. These fish apparently had a very high survival rate, as fewer marked fish have been found in succeeding experiments.

Of the 382,300 troll-caught silvers landed in Oregon and the Washington side of the Columbia River in 1947, 35,000 were examined or 9.2 percent of the catch. In this sample there were found 260 marks of the 1944 brood year marking of 199,497 fish. Calculating the number of marked fish in the catch from these data gives 2,843, with a marked to unmarked ratio of 1 : 135. This indicates a recovery by the Oregon and Columbia River troll fishery in 1947 of 1.4 percent of the total number of marked fish. Some marked fish from these experiments were also recovered in 1948, which would raise the percentage recovered even higher.

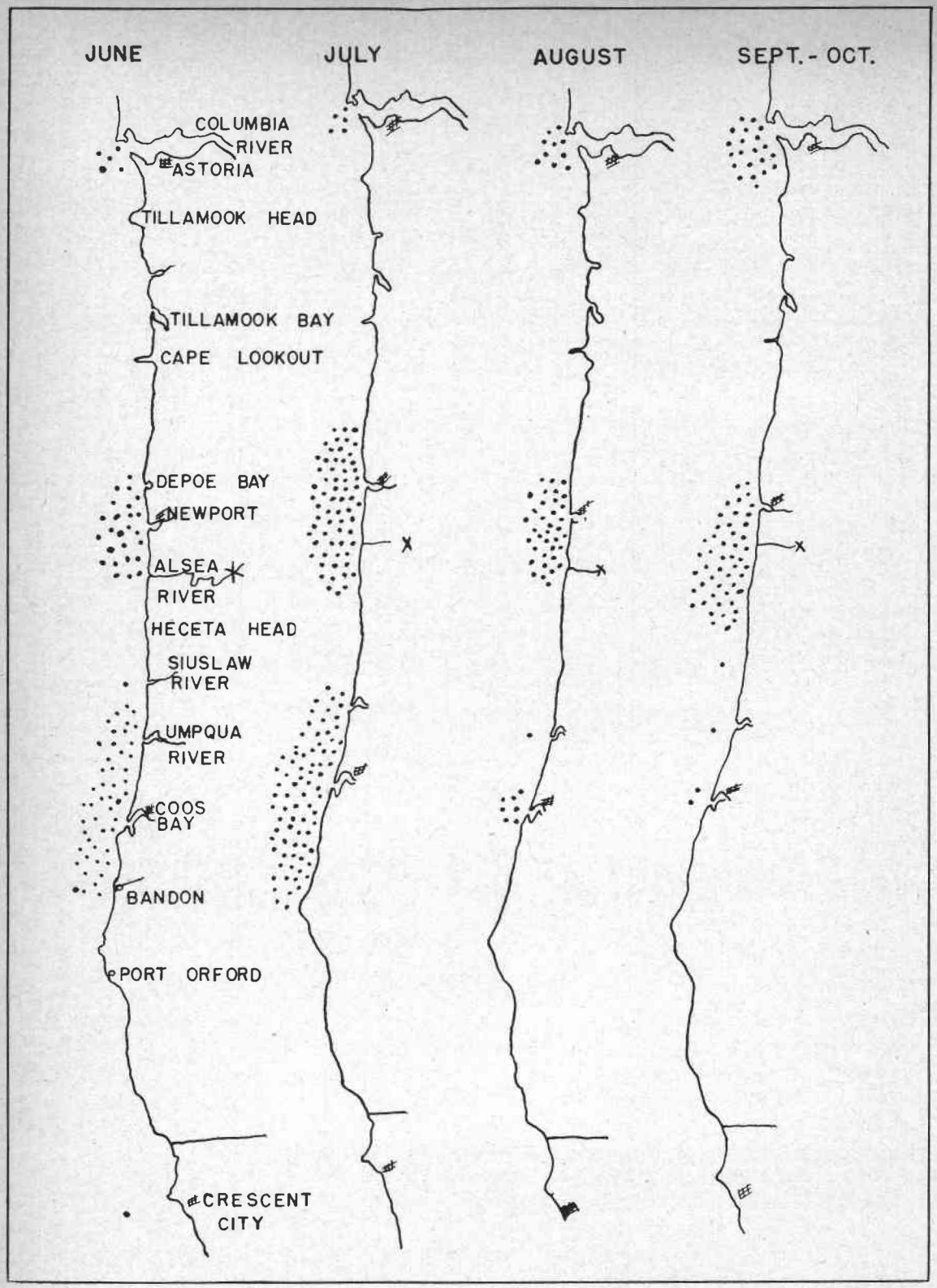

FIGURE 4. Ocean recoveries of Alsea River Silver Salmon marks of the 1944 brood year (Also showing distinguishing features of the Oregon Coastline).

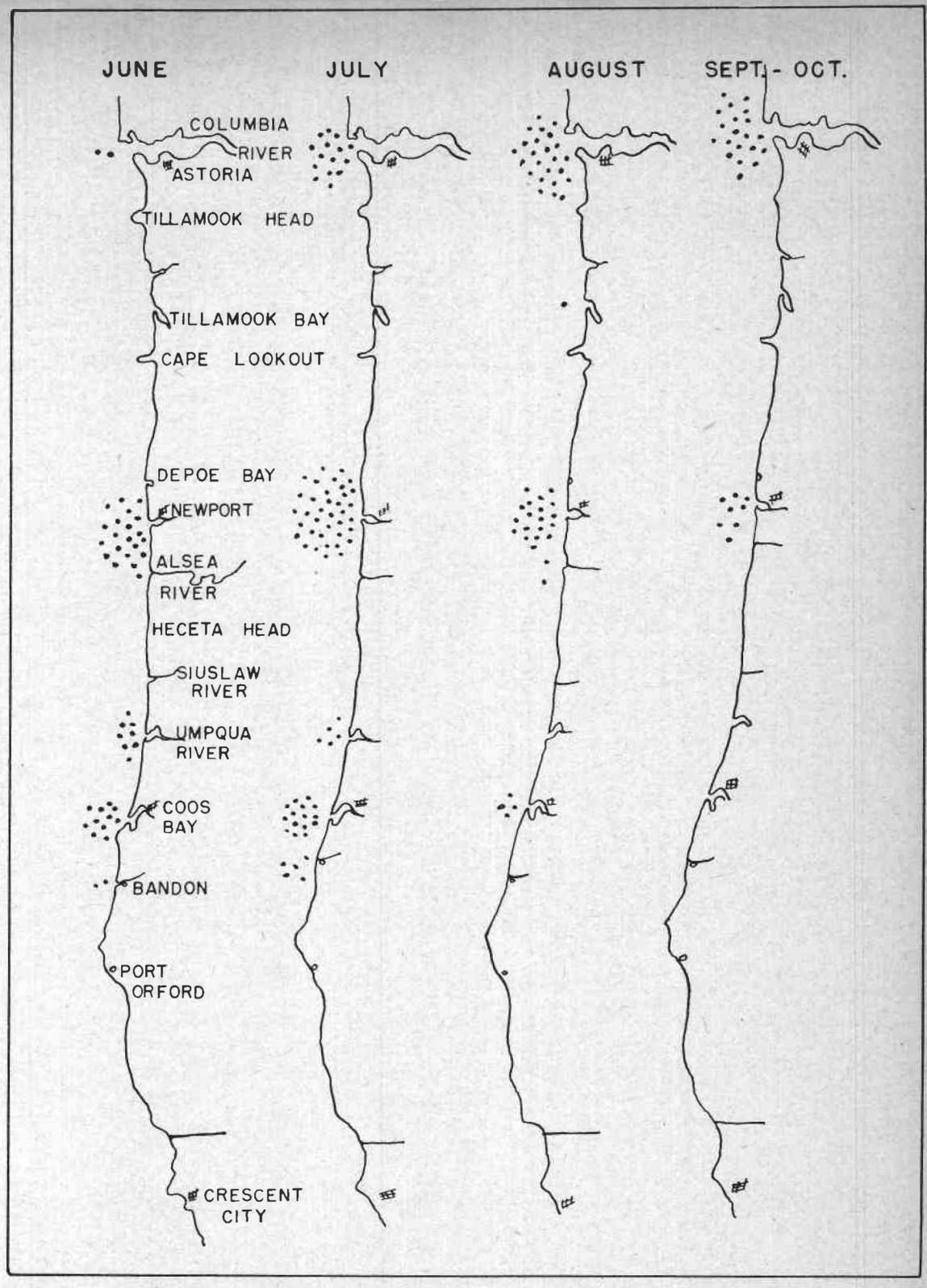

FIGURE 5. Ocean recoveries of Bonneville silver salmon marks of the 1944 brood year.

The returns from similar markings in 1948 are not as high. The catch in 1948 was 320,695 fish of which 30,183 (9.4 percent) were examined for marks. There were 110,308 fish marked that year (1945 brood year), but only five of them were recovered. In addition seven other marks of uncertain origin were found which have been tentatively assigned to the 1944 brood year.

These marks were obtained by sampling the catch; no reward was offered and no effort was made to collect marks other than by sampling. The marked to unmarked ratio was 1 : 6,037, with the calculated number of marked fish in the catch being 54. Only 0.05 percent of the marked fish of the 1945 brood year were recovered by the troll fishery. In 1949, 11,385 silvers were examined and one mark was found, a ratio of 1 : 11,385. Only 14,609 were marked of the 1946 brood year which of course accounts for the paucity of marks.

In 1948 and 1949 a record was kept of the single fin clips observed in the sampling. From the sample of 30,183 in 1948 the following single marks were noted:

Adipose—11	A ratio of	1 : 2,744
Left Ventral—8	A ratio of	1 : 3,773
Both Ventrals—7	A ratio of	1 : 4,312
Right Pectoral—7	A ratio of	1 : 4,312
Right Ventral—6	A ratio of	1 : 5,030
Left Pectoral—2	A ratio of	1 : 15,091
Both Pectorals—1	A ratio of	1 : 30,183
Dorsal—1	A ratio of	1 : 30,183

In 1949 the following were noted:

Adipose—10	A ratio of	1 : 1,138
Right Ventral—6	A ratio of	1 : 1,898
Both Ventrals—4	A ratio of	1 : 2,846
Left Ventral—2	A ratio of	1 : 5,692
Right Pectoral—2	A ratio of	1 : 5,692
Left Pectoral—1	A ratio of	1 : 11,385

Due to the small number of returns, very little can be said about migration from the 1948 or 1949 data. In 1948, fish from Bonneville were reported off Astoria, Newport, and Coos Bay, and one mark from Minter Creek in Puget Sound was found off Newport. In 1949 a silver from Sand Creek on Tillamook Bay was landed at Astoria.

If the conditions which promoted such an excellent recovery of the 1944 brood year can be repeated with the 1949 brood year a great deal of data concerning the movements of these marked fish can be anticipated from marking experiments. If, however, conditions for survival are poor, as they apparently were for the 1945 brood year, the results may not be up to expectations.

Condition and Mortality of Hooked Fish

Whenever time permitted on board the salmon trollers during 1948 and 1949, observations were made as to the condition of the fish tagged and where they were hooked. In 72 days spent tagging, there were 794 silvers caught. Of these, 506 were tagged and 288 were kept by the fishermen, and of the 794 caught, only 15 or 1.9 percent were dead when landed. There were 569 (71.7 percent) hooked in upper or lower jaw, corner of mouth, or cheek; 64 (8.1 percent) were hooked in the gills, eye, or throat; 3 (0.3 percent) were foul-hooked in the back or operculum, and observations were not made on 143 (18.0 percent).

Condition of the tagged fish was judged as good if it swam away rapidly; fair—swam away slowly at surface and appeared stunned; poor—floated away. Table 3 summarizes the data on the condition and place of hooking of the tagged silvers and the numbers of each category which were returned. The number of returns is not sufficient to warrant a statistical analysis; however, the fact remains, and, contrary to popular opinion, that fish which are hooked in the gills or eye or which float away will often live. From Table 3 it can be seen that the percentage of recoveries from fish which were released in poor condition (5.9 percent) is similar to that of fish released in good condition (6.8 percent). Likewise the recoveries from fish which were hooked in the gills or eye (5.0 percent)

compares favorably with the percentage recovery of those which were lightly hooked. From these rather scanty data it would appear that there is very little difference in survival of tagged silver salmon which were lightly hooked and those severely hooked in the eye or gills.

TABLE 3. CONDITION OF TAGGED SILVER SALMON AT TIME OF RELEASE, OREGON

	Tagged		Recovered		Percent of Number Recovered from Each Tagging Category
	Number	Percent	Number	Percent of Total Number Recovered	
Good (1)	311	61.5	21	72.4	6.8
Fair (2)	109	21.5	3	10.3	2.8
Poor (3)	85	16.8	5	17.2	5.9
Unknown	1	0.2	0	0.0	0.0
	506		29		
Hooked in:					
Jaws, cheek, etc.	394	77.9	24	82.8	6.1
Gills, eye, etc.	40	7.9	2	6.9	5.0
Miscellaneous	3	0.6	0	0.0	0.0
Unknown	69	13.6	3	10.3	4.4
	506		29		

The Length-Weight Relationship of Troll-Caught Silver Salmon

Numerous observations have been made to obtain the length and weight of troll silver salmon in an effort to obtain an accurate length-weight curve. Information on the length-weight relationship is needed in growth and age studies to convert average lengths to average weights and vice versa, to convert pounds of fish into numbers of fish, to evaluate size limits, and to learn something of the condition of the fish.

The weights given are all dressed weights (heads on), taken with a spring scale, accurate to one-tenth of a pound. The lengths are fork lengths, measured from the tip of the snout to the fork of the tail. In 1947 total lengths to the nearest inch were taken, and were then converted to fork lengths in centimeters. In 1948 fork lengths were taken to the nearest centimeter.

The weights taken for each centimeter of length were averaged and the weighted mean was used in the calculations. Only the data between 50 and 80 centimeters, inclusive, were used in calculating the curve (Table 4).

It is customary in curve fitting to plot the points to be fitted on various scales to determine the best type of curve to fit the data. If the points form a straight line on standard coordinate paper a linear relationship is indicated. If they form a straight line when a regular scale is used on one axis and a logarithmic scale on the other axis (semi-log) an exponential type of curve, of the type $W = AB^L$ (Snedecor, p. 374) is indicated. If the points form a straight line when both the horizontal and vertical axis are a logarithmic scale (log-log), a parabolic curve of the type $W = AL^b$ is indicated. The latter equation is the usual form of the length-weight relationship as given by Keys (1928), Clark (1928), and others. In these equations W = weight, L = length, and A and B are empirically determined constants.

This procedure was followed for the 1947 and 1948 data, and it was found that the points fell in a reasonably straight line on both the semi-log and the log-log scale. However, a close examination showed that the points plotted on a log-log scale formed a definite curve and did not fit the straight line as well as when they are plotted on a semi-log scale. The relative deviations of the points from the straight line on the two types of scales are especially striking in 1948 when large samples were obtained.

Figure 6 shows the calculated exponential curve for the two years. The curve below 50 centimeters and above 80 centimeters is extrapolated. These curves fit the empirical data very closely although they do not originate at zero. The parabolic curves plainly did not fit the points as well as the exponential curves, so it was concluded that the exponential equation best expresses the

TABLE 4. THE LENGTH-WEIGHT RELATIONSHIP OF TROLL-CAUGHT SILVER SALMON, OREGON

1947

Total Length In Inches	Fork Length In Centimeters	Number of Weights	Average Weight
21	49.93	43	3.3
22	52.38	110	3.5
23	54.84	180	4.0
24	57.29	281	4.6
25	59.75	307	5.2
26	62.20	277	6.0
27	64.66	243	6.7
28	67.11	151	7.8
29	69.57	114	8.8
30	72.02	84	10.0
31	74.48	69	11.1
32	76.93	43	12.4
		Total 1,902	

1948

Fork Length In Centimeters	Number of Weights	Average Weight	Fork Length In Centimeters	Number of Weights	Average Weight
40	3	1.8	63	187	5.8
41	1	1.8	64	217	5.9
42	3	2.1	65	227	6.2
43	2	2.0	66	232	6.6
44	1	2.6	67	229	6.8
45	4	2.3	68	251	7.2
46	3	2.5	69	236	7.6
47	5	2.5	70	204	8.0
48	17	2.6	71	143	8.5
49	9	2.9	72	130	8.8
50	30	3.0	73	98	9.2
51	27	3.2	74	90	9.8
52	45	3.4	75	65	10.3
53	75	3.6	76	44	10.8
54	84	3.7	77	31	11.3
55	83	3.9	78	18	12.0
56	90	4.2	79	14	12.5
57	126	4.3	80	12	12.8
58	118	4.5	81	3	13.1
59	148	4.7	82	3	14.9
60	181	5.0	83	5	14.2
61	160	5.1	84	2	13.6
62	165	5.5	85	0	
			86	1	16.6
				Total 3,822	

length-weight relationship of dressed troll-caught silver salmon in the given size ranges. The equation for 1947 is $W = 0.23215 \times 1.0535^{L}$ and for 1948, $W = 0.27952 \times 1.04949^{L}$. This is the first published case that has come to the writer's attention where the length-weight relationship does not conform to the usual parabolic length-weight equation but instead fits the exponential type of curve.

There is a considerable difference in the length-weight relationship between the two years. The fish in 1947 were heavier for the same length than in 1948. Between 60 and 70 centimeters, which includes most of the catch, there is a difference of about half a pound.

Relationship Between Fork and Total Lengths

The biological measurements are measured to the fork of the tail for reasons of uniformity, while the fishermen measure to the tip of the tail in observing the size limits. It is, therefore, essential to be able to convert one measurement to the other. Total length measurements were taken from the tip of the snout to the end of the caudal rays in the normal position and also with the rays extended to their maximum limit. The total length measurement with the tail extended was considered to be superior to the measurement taken with the tail in the normal position. Regression

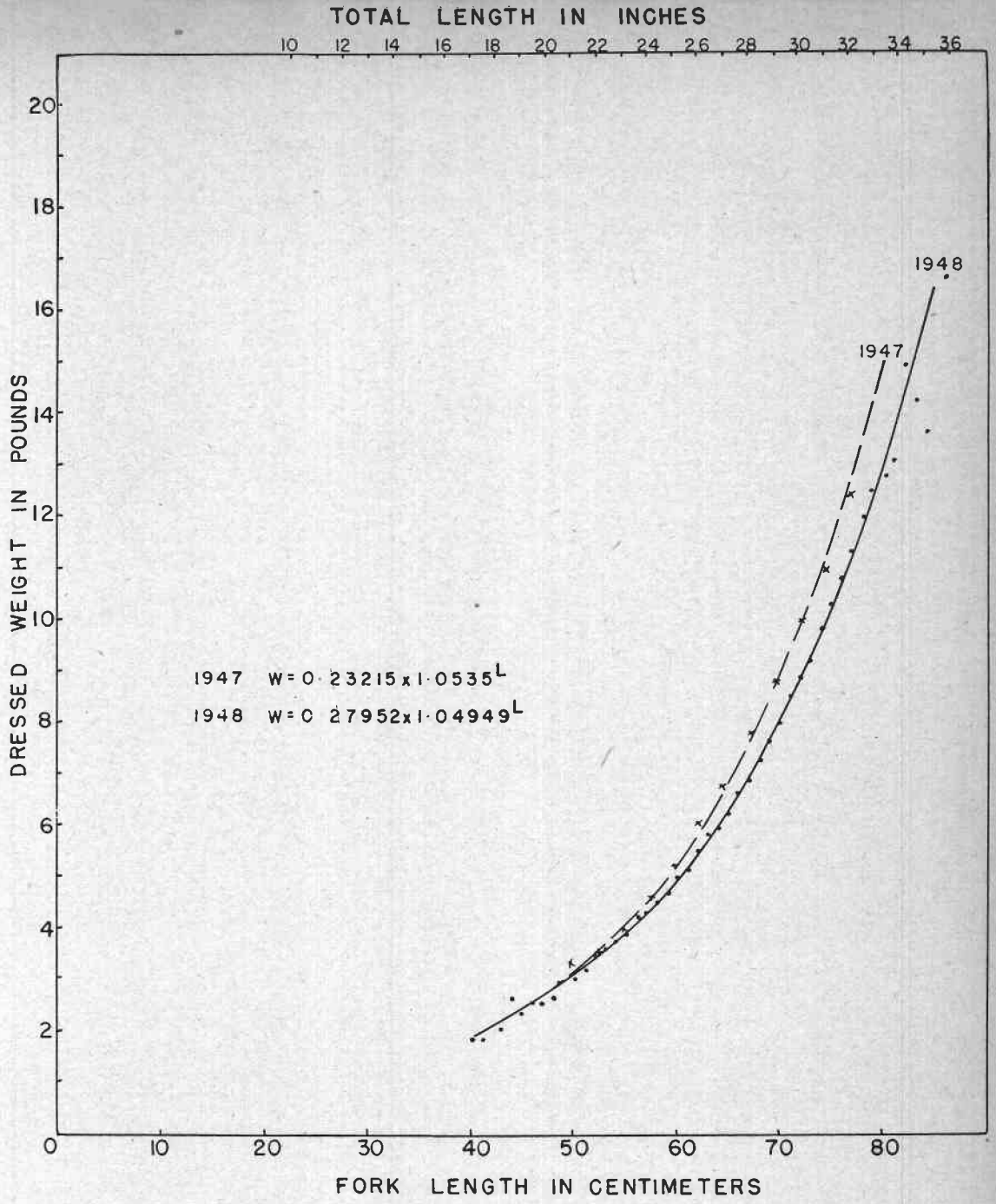

FIGURE 6. The length-weight relationship of troll-caught silver salmon, exponential curves.

lines were calculated for 218 measurements with the tail in normal position and for 330 measurements with the tail extended. The formulae for the lines are given in Table 5 and they can be used to convert from one measurement to the other.

TABLE 5. FORMULAE FOR CONVERTING FORK AND TOTAL LENGTHS OF SILVER SALMON

Tail in Normal Position:	TL (cm.)=1.67995+1.03467 FL (cm.)
Tail Extended:	TL (cm.)=1.78433+1.03706 FL (cm.)

Growth of Silver Salmon

Silver salmon are extremely fast growing animals, and it has long been known that they double their weight during their third and last summer (Smith, 1920). Previous work has shown that the commercial catch of silver salmon is largely of one year class, i.e., fish in their third year (Gilbert, 1913), (Pritchard, 1940). The average weights of the silvers through the season show an increase which has been attributed to the growth of this dominant year class.

Average weights have been obtained for the past three years at ports along the Oregon Coast and are shown on a weekly basis in Figure 7.

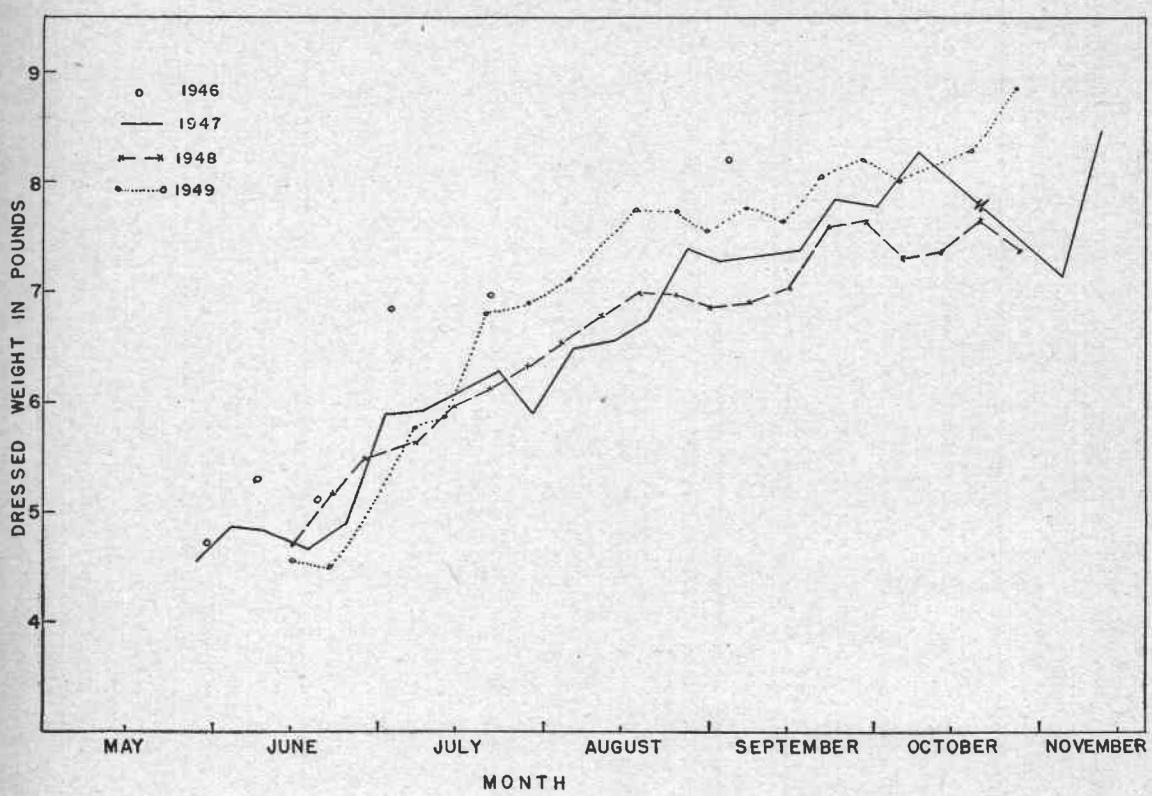

FIGURE 7. The weekly average weights of troll-caught silver salmon, Oregon.

Scattered observations at Reedsport in 1946 are shown by the circles. There seems to be quite a difference in the growth rate of the different years, but a line fitted by inspection to the three year's data shows an increase in mean weight from about four and a half pounds on June first to eight pounds on November first. The 1949 data indicate that the silvers had a faster growth rate and a much higher average weight in 1949 than the previous two years, and it may have been even higher in 1946.

The growth can perhaps better be shown by an analysis of the length-frequency curves. The mode of the length-frequency should be the mode of the third year class, and not include the possible influence of other minor year classes. The length-frequency curves are shown on a monthly basis in Figure 8 for 1948.

The movement of the mode to the right as the season progresses is plainly evident and may be interpreted as growth, although the migration of larger races into the area could also cause a similar phenomenon.

The length-frequency data were weighted by the number of fish landed; thus, the curves actually show the number and size of the fish landed, not just the size of the sample during the period. The season was closed during most of June which accounts for the small landings during that period; this would also cause the average weight and length-frequency data to be higher than actually is the case, since the fish were landed in the last two weeks of the month. The mode for the different

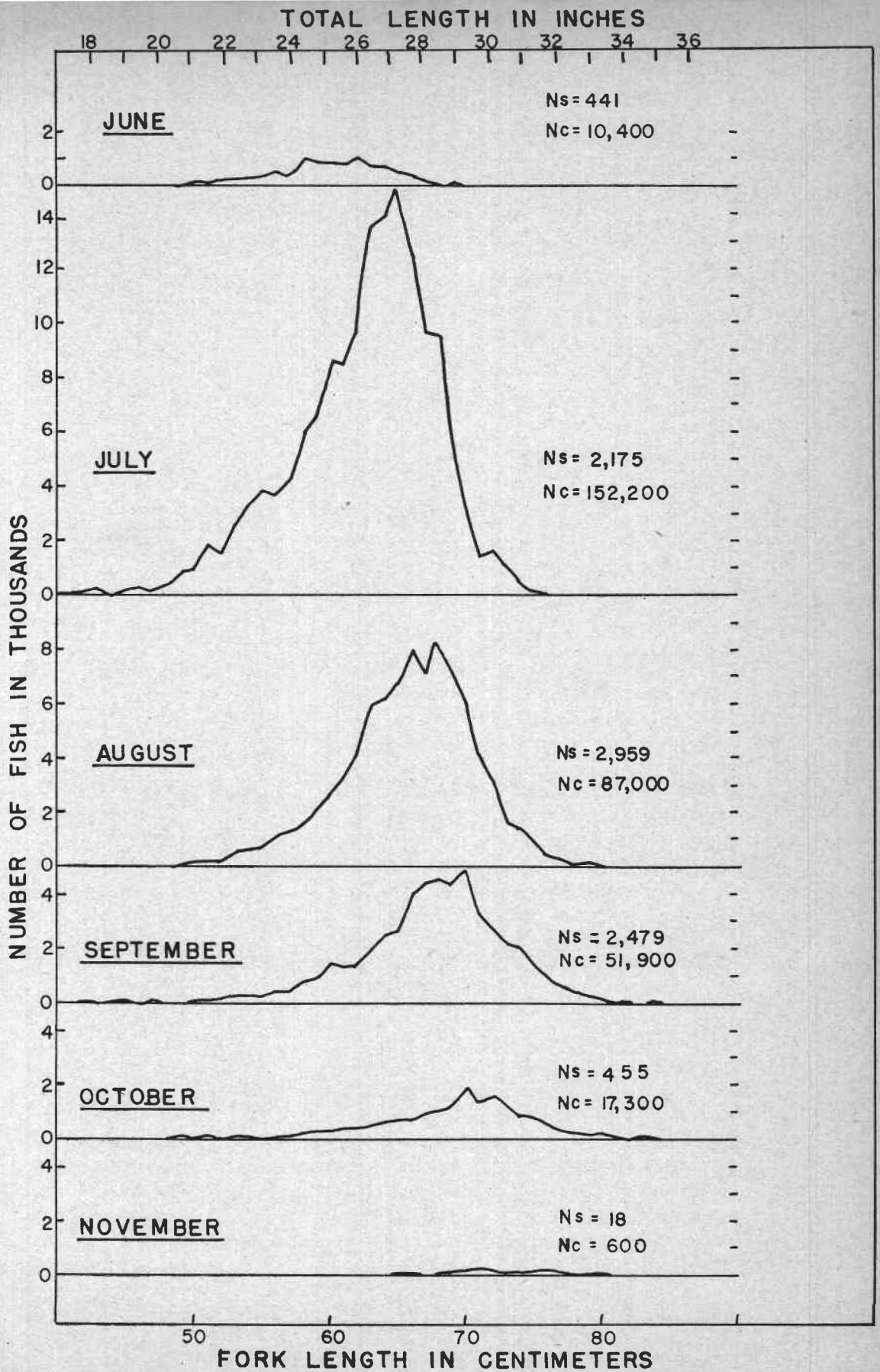

FIGURE 8. Monthly length-frequency of the Oregon and Columbia River troll silver salmon catch in 1948. Weighted by the numbers of fish landed.

months has been calculated by the method used by Brock (1943); i.e., the mean of the five adjacent classes that contained the greatest numbers of individuals was taken as the mode. Figure 9 shows that the modal lengths form a very uniform growth rate, with an increase from 60 centimeters (25.2 inches total length) during June to 72.7 centimeters (30.4 inches total length) during November.

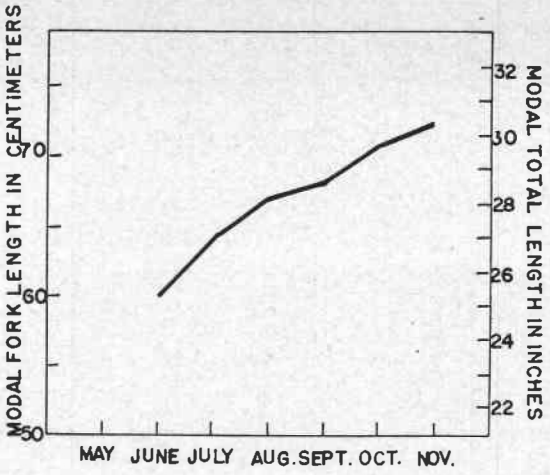

FIGURE 9. The monthly increase in modal length of troll-caught silver salmon in 1948.

THE CHINOOK SALMON FISHERY

Migration

TAGGING EXPERIMENTS

The early attempts at tagging salmon at sea were discussed in the section on silver salmon; there were two chinook recoveries from the 1926 and 1927 tagging of 140 chinook salmon. One tagged off the Nehalem River on August 4, 1926 was recovered at the Big White Salmon River Hatchery, Columbia River, and another tagged off Coos Bay in early September, 1926 was recovered ten days later in the Coos River.

The work done by the Canadians off Vancouver Island and the Queen Charlotte Islands from 1925 to 1930 is summarized by Pritchard (1934) and has been previously mentioned in connection with the silver salmon migration. The Canadian work implies that the young chinook salmon leave their natal streams and make what Mottley (1929) has termed a northwesterly "feeding" or "dispersal" movement. The young fish from the coastal waters of Washington, Oregon, and California, but particularly the Columbia River, disperse north along the American and British Columbian coasts. Undoubtedly some of them also turn southward but the extent of this is not known. At some time in their life history the salmon turn from their slow feeding migration in the ocean and make a rapid southward journey to their natal streams. It was found that as the tagging moved northward the recoveries in United States waters became fewer. The Columbia River contributed by far the greatest percentage of the returns, but nearly every Oregon coastal stream was represented to some extent.

Tagging chinook salmon off the west coast of Baranof Island in 1926 and 1927 by the United States Bureau of Fisheries (1928) resulted in a 60 percent recovery from the Columbia River.

A start has been made in determining the migrations of chinook salmon off the Oregon coast, but with the present data, one can do little more than speculate at the origin of the stocks. In 1948 arrangements were made to accompany the trollers and tag undersize chinooks, those less than the legal length of 27 inches, and in 1949 undersized fish were again tagged in addition to some larger fish which were purchased for tagging. The recoveries were relatively few, probably due largely to the fact that most of the fish were small and had several years of ocean life before maturity. It is possible that more will be recovered in future years. Tables 6 and 7 summarize the tagging and recoveries and Figure 10 shows the migration routes of the recovered fish.

TABLE 6. TROLL CHINOOK SALMON TAGGING, OREGON

Area	1948			1949			Total		
	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered
Columbia River.	6	1	16.7	54	4	7.4	60	5	8.3
Newport.....	15	0	0.0	8	0	0.0	23	0	0.0
Coos Bay.....	88	5	5.7	50	1	2.0	138	6	4.4
Total.....	109	6	5.5	112	5	4.5	221	11	5.0

TABLE 7. TROLL CHINOOK SALMON TAG RECOVERIES, OREGON TAGGING
(Tagged in 1948–49, Recovered in 1948–49)

TAGGED			RECOVERED				
Tag No.	Date	Location	Date	Location	Days Out	Migration	Gear
D-222	29 April 1948	Off mouth Col. R.	9 Sept. 1948	Celilo Falls	153	170 E.	Col. R. seine
C-769	22 July 1949	do.	7 Sept. 1949	Lewis River, Wash.	57	80 E.	Sport
C-742	13 July 1949	Off Tillamook Head	1 Dec. 1949	Tuolumne R., Cal.	141	650 S.	?
R-100	17 June 1948	Off Coos Bay	19 Sept. 1948	Off Nehalem R., Ore.	94	135 N.	Troll
B-627	4 July 1948	do.	21 Aug. 1949	Off Sea Lion Caves	413	50 N.	Troll
B-626	4 July 1948	do.	7 Aug. 1949	Off Newport, Ore.	399	70 N.	Troll
B-658	27 July 1948	Off Port Orford	24 Oct. 1948	Sixes River, Ore.	89	10 N.	Sport
C-792	20 Sept. 1949	Off Nehalem R.	2 May 1950	Ucluelet, B. C.	224	200 N.	Troll
C-728	7 July 1949	Off Columbia R.	25 June 1950	Umatilla	353	135 N.	Troll
B-641	27 July 1948	Off Port Orford	21 June 1950	Farallone Islands, Cal.	694	290 S.	Troll
F-545	16 Aug. 1949	Off Coos Bay	1 Aug. 1950	Trinidad Head, Cal.	350	105 S.	Troll

The northerly migration of the three fish from Coos Bay and the two from off the Columbia River strongly suggests a northerly feeding migration from some southern stream, while the recovery in the Tuolumne River, California of a fish tagged off the Columbia River indicates a rapid southward journey to its home stream. The two which were tagged in the Coos Bay area and recovered one and two years later off California may have made a more extensive northward migration before returning south. These two fish may have been on a southward feeding migration from the Columbia or other northern rivers. The two which were tagged off the Columbia River and later recovered in the Columbia River were "jacks," precociously mature males, as was also the one recovered in the Sixes River in southern Oregon.

Tagging efforts are now being concentrated on the chinooks, and a great deal of work remains to be accomplished before the complex migration pattern of the chinook salmon is comprehended.

To date most of the recoveries have been made in the ocean, and it is impossible in this case to assign the fish to their proper stream system. Until more chinooks have been recovered in the rivers it will not be possible to determine the composition of the stocks along the Oregon Coast. In an effort to obtain more river recoveries, many large chinooks are now being tagged, and since it is also important to know the origin of the small fish, an improved type of strap tag is on experimental trial. It is hoped that this tag will allow the fish to grow normally to adult size without losing the tag or covering it over with flesh, and it also appears to cause less resistance to the passage of water and should lessen the chances of irritation and infection.

MARKING EXPERIMENTS

There has been no really systematic recovery of marked chinook salmon in the ocean. Rich and Holmes (1928) reported one of their Columbia River marks from Dixon Entrance in S. E. Alaska and two off Vancouver Island from various marking experiments. Their most successful experiment was in the spring of 1923, when 100,000 fall chinook were released at the Big White Salmon River Hatchery on the Columbia River. Eighteen of these were recovered in the troll fishery and 435 in the river fishery and at the hatchery. Ten of the 18 troll recoveries were made

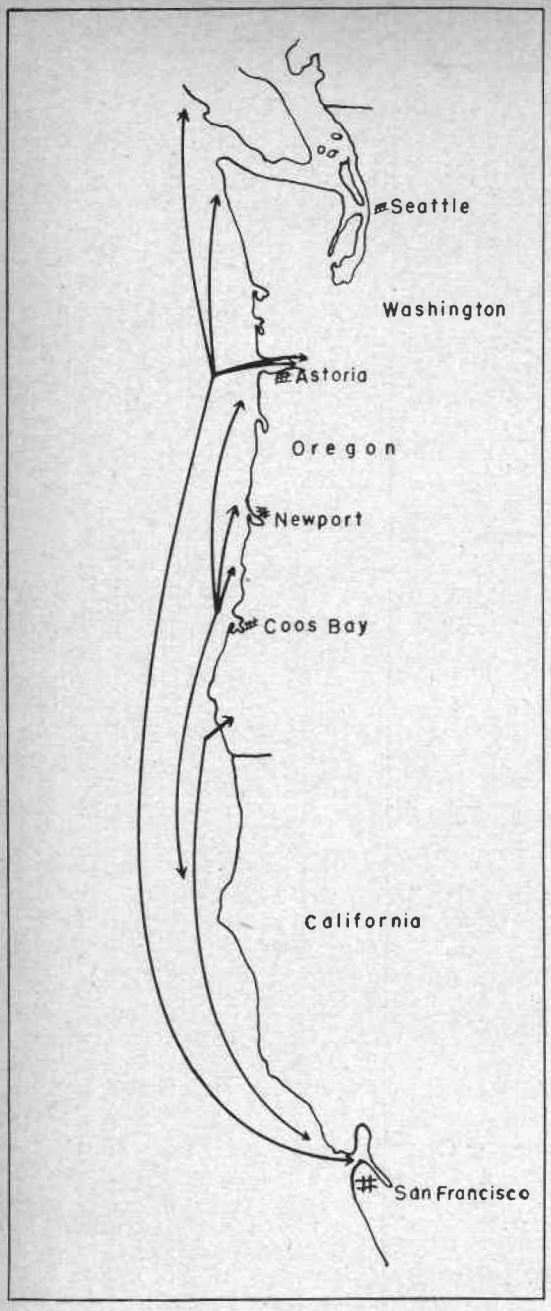

FIGURE 10. Migration of Chinook Salmon tagged off the Columbia River and coastal areas of Oregon in 1948 and 1949.

off the mouth of the Columbia River in 1925 (fish in their third year, 2+), three off the Columbia River and two off Vancouver Island in 1926 (3+), and three off the Columbia River in 1927 (4+). Since most of the recovery effort was directed at the Columbia River, it is to be expected that most of the recoveries should be from that area. Undoubtedly many of these fish were taken along the coast, and the marks not recovered. The records indicate that some of these marked fish were to be found within a short distance of the mouth of the Columbia River during the entire fishing season from May to September.

In 1947 emphasis was placed by the Fish Commission on the recovery of silver salmon marks and little was done with chinook marks. A few chinook salmon marks were found incidental to other activities, but the ratio of marked to unmarked is not known. The marks were turned over to the U. S. Fish and Wildlife Service. These were Columbia River marks and were recovered off Newport and Coos Bay, indicating that Columbia River chinooks do migrate to the south to some extent.

In 1948, 14,213 fish were examined out of a catch of 146,327 fish, and 13 marks were found. Again marks were duplicated on the Sacramento and Columbia Rivers, and it is impossible to assign them to their respective home streams. Five of the fish were recovered in their third year, seven in their fourth year, and one in its fifth year. The Fish and Wildlife Service paid a reward for the recovery of their marks in 1947 and 1948 and they recovered many additional marks from the troll fishery. In 1949, 7,173 chinooks were examined and three marks were found. These were Columbia River fish taken off the mouth of the Columbia River in their third year (2+).

Condition and Mortality of Hooked Fish

In the 72 days spent tagging there were 393 chinook salmon caught. Of these, 10 (2.5 percent) were dead when landed; 243 (61.8 percent) were hooked in the jaw or cheek; 41 (10.4 percent) were hooked in the eye, gills, or throat; and on 99 (25.2 percent) the place of hooking was not noted. Table 8 gives the condition and the place of hooking of the tagged fish. These data do not warrant any conclusions about the relative survival of the different condition categories; however, it may be noted that about the same proportion of fish in category 3 (poor when released) were recovered as those fish in category 1 (good condition when released). There seems to be a tendency for chinooks to be hooked in the gills or eye slightly more often than silvers, and a higher percentage are dead when landed. This is possibly due to the greater depth at which they are usually taken. However, the condition of the fish when released is better, since the chinooks do not fight as strenuously as silvers and are easier to unhook without injury.

TABLE 8. CONDITION OF TAGGED CHINOOK SALMON AT TIME OF RELEASE, OREGON

	Tagged		Recovered		Percent of Number Recovered From Each Tagging Category
	Number	Percent	Number	Percent	
Good (1)	174	78.7	10	90.9	5.8
Fair (2)	29	13.1	0	0.0	0.0
Poor (3)	18	8.1	1	9.1	5.6
	221		11		
Hooked in:					
Jaw, cheek	135	61.1	7	63.6	5.2
Gills, eye	26	11.8	0	0.0	0.0
Unknown	60	27.1	4	36.4	6.7
	221		11		

Relationship Between Fork and Total Lengths

Again measurements were taken with the tail in its normal position and with the rays extended to determine the difference in measurements of length taken by these two methods. Two hundred and twelve measurements with the tail in normal position and 462 measurements with the tail extended were used in calculating the formulae for converting one measurement to the other; the formulae are given in Table 9.

TABLE 9. FORMULAE FOR CONVERTING FORK AND TOTAL LENGTHS OF CHINOOK SALMON

Tail in Normal Position:	TL (cm.) = 1.41281 + 1.04389 FL (cm.)
Tail Extended:	TL (cm.) = 1.71728 + 1.05625 FL (cm.)

The Length-Weight Relationship of Troll-Caught Chinook Salmon

These data were treated in the same manner as for silver salmon. Table 10 gives the empirical data; the points plotted on a semi-log scale showed a definite curve to the line, indicating that the exponential curve would not fit the data; plotting the data on a log-log scale straightened the curve almost to a straight line. The parabolic relationship ($W = AL^b$) was accordingly considered to more accurately depict the length-weight relationship for chinook salmon. It is strange that such closely related fish as the chinook and silver salmon should have different length-weight relationships. These unusual relationships may be related to the fact that the fish were dressed with the heads on when the lengths and weights were taken. Figure 11 (page 67) shows the calculated curves for the two years with the empirical data. The equation for 1947 is $W = .000013126\ L^{3.17008}$, and for 1948 $W = .000009256\ L^{3.24142}$. The chinook, like the silver salmon, were heavier in 1947 for any corresponding length than during the 1948 season.

Size and Age Composition of the Troll Chinook Salmon Catch Off Oregon

Unlike the silver salmon, the catch of which consists largely of one year class with a fairly constant life history, the chinook salmon catch consists of several year classes. It is further complicated by the varying lengths of time the fingerlings stay in fresh water, by the different ages at which they mature and leave the ocean, and by the different growth rates and sizes of the many races.

The technique of stratified sub-sampling was used in determining the age composition of the catch; this method has been used by the International Fisheries Commission in their study of the Pacific halibut and by Fridriksson (1934) studying the cod of the North Atlantic. Many random length-frequency measurements were taken, and scale samples were selected to cover the entire range of sizes. The percentage age composition of each length was determined, and from the random length-frequency distribution the age composition was computed.

The works of Gilbert (1913), Rich (1925), and Mattson (unpublished ms., 1949) were used as criteria in interpreting the scales. They recognized two principal types of early scale growth. Scales

TABLE 10. THE LENGTH-WEIGHT RELATIONSHIP OF TROLL-CAUGHT CHINOOK SALMON, OREGON

1947

Total Length in Inches	Fork Length in Centimeters	Number of Weights	Average Weight	Total Length in Inches	Fork Length in Centimeters	Number of Weights	Average Weight
20	47.31	12	2.9	32	76.51	60	12.6
21	49.74	10	3.5	33	78.94	42	13.0
22	52.18	6	3.3	34	81.39	37	15.1
23	54.61	5	4.5	35	83.81	32	16.3
24	57.04	3	5.0	36	86.24	46	17.8
25	59.48	5	5.7	37	88.68	24	20.2
26	61.91	13	6.2	38	91.11	19	22.3
27	64.34	16	6.6	39	93.54	18	25.4
28	66.78	18	8.1	40	95.98	14	24.8
29	69.21	62	8.7	41	98.41	3	26.2
30	71.64	51	9.7	42	100.84	2	31.0
31	74.08	56	11.1	43	103.28	3	32.3

1948

Fork Length in Centimeters	Number of Weights	Average Weight	Fork Length in Centimeters	Number of Weights	Average Weight	Fork Length in Centimeters	Number of Weights	Average Weight
40	1	1.6	63	192	6.3	86	65	17.4
41	1	2.1	64	233	6.6	87	52	18.3
42	0		65	203	6.9	88	43	18.3
43	0		66	183	7.2	89	55	19.2
44	3	2.3	67	156	7.6	90	52	20.0
45	0		68	135	7.8	91	33	20.4
46	1	2.6	69	121	8.4	92	34	21.4
47	0		70	140	8.9	93	30	22.4
48	6	2.6	71	105	9.2	94	21	22.7
49	2	2.7	72	108	9.8	95	22	24.1
50	6	3.0	73	77	10.0	96	17	25.1
51	2	3.2	74	90	10.7	97	15	26.0
52	9	3.5	75	92	11.0	98	11	26.7
53	9	3.9	76	79	11.5	99	6	26.6
54	5	4.6	77	92	11.8	100	11	28.6
55	10	4.5	78	85	12.6	101	4	28.7
56	17	4.5	79	85	13.0	102	7	30.5
57	18	4.7	80	100	13.7	103	1	29.0
58	33	5.0	81	77	14.2	104	3	28.8
59	57	5.4	82	72	14.7	105	2	34.0
60	93	5.5	83	61	15.4	106	1	32.0
61	151	5.8	84	71	15.8	107	4	33.2
62	220	6.0	85	64	16.4	108	2	43.0

from salmon which went down to the sea during their first year were regarded as having "ocean" nuclei, and those from salmon which stayed in the stream a full year were regarded as having "stream" nuclei. There are, of course, many combinations of these two principal types, including those which apparently spent some time in the estuary or brackish water. In this paper the age is given by the number of annuli counted, i.e., a fish with the age of 3+ would have three annuli and would be in its fourth year.

Three scales from every fish were mounted by the celluloid impression method. They were first studied with the high power of a binocular dissecting microscope, and the three age readings were recorded. They were later examined with a projector, and those three readings were also recorded without reference to the previous readings or the length of the fish. If the six readings agreed as to type of nucleus and age, that was considered to be the age; if they did not agree, the scale was again examined under the microscope and the most logical interpretation accepted. A few were discarded as being too doubtful. Of the 374 scales examined for the years 1946 and 1947, 267 agreed on all six readings, 97 did not agree on all six readings, but the age was determined with no great doubt as to its accuracy; ten were discarded.

The first observations on the age of chinook salmon in the troll catch of Oregon were made in 1919 by Dr. Rich. He compared the ages of chinook salmon found in the ocean off the Columbia

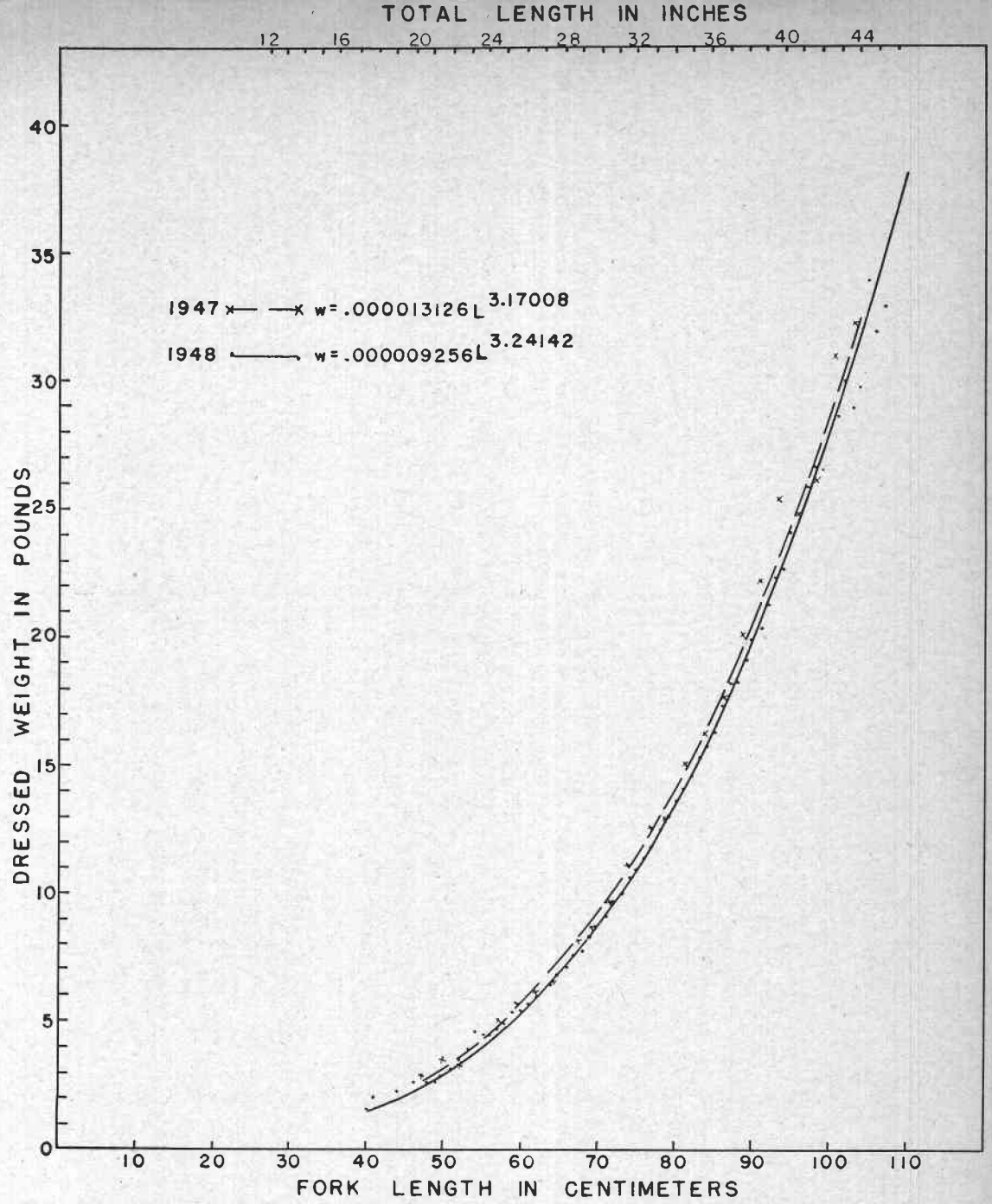

FIGURE 11. The length-weight relationship of troll-caught Chinook Salmon, Oregon.

River with those found inside the river. More recent observations were begun by the Oregon Fish Commission in 1946 at Reedsport. During May, June, July, and September, 362 length-frequency measurements were taken, and 73 scale samples were taken between May 20 and June 11. Figures 12 and 13 show the length-frequency and the percentage age composition of each inch of length for 1946.

As can be seen, the 2+ group is the dominant year class in this sample. The computed percentages of the various year classes in the sample are as follows: 8.51 percent were 1+; 67.13 percent were 2+; 23.65 percent were 3+; and 0.07 percent were 4+. This probably does not represent the true age composition of the catch inasmuch as no samples were taken during August, the

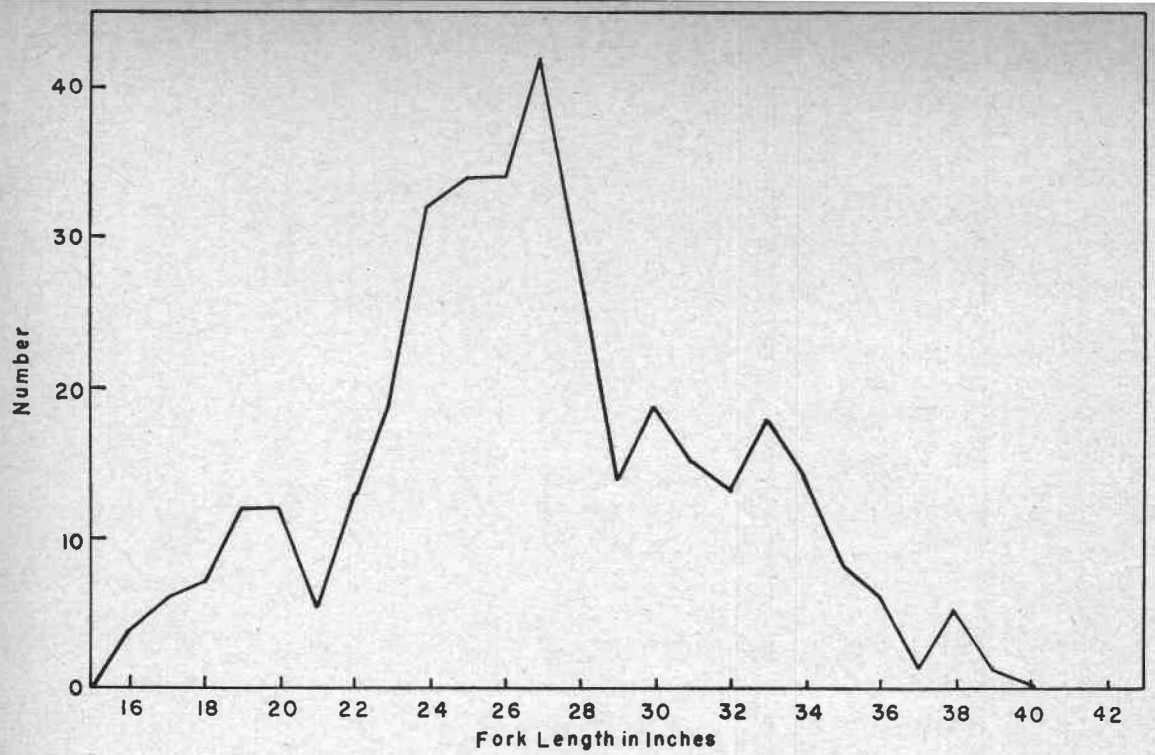

FIGURE 12. Length-frequency of troll-caught Chinook Salmon, sampled at Reedsport, Oregon, in 1946.

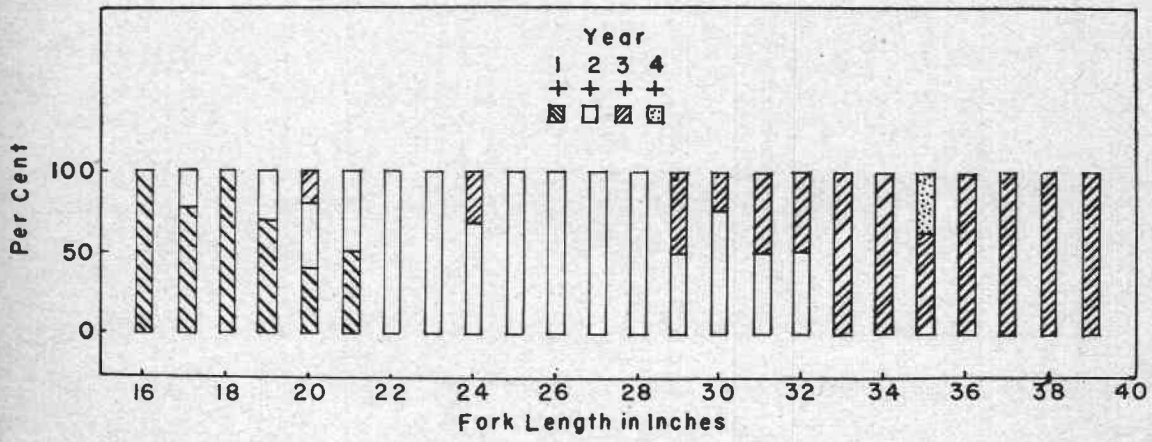

FIGURE 13. The percentage age composition for each inch of length of troll-caught Chinook Salmon in 1946.

sampling may not have been in direct proportion to the catch, and it was confined to one port; but it does indicate the preponderance of small immature 2+ fish found during May, June, July, and September, 1946, off the Umpqua River. Although a size limit of only 20 inches (total length) was enforced, the number of 1+ fish was still relatively small. Due to the small sample, the final analysis is not separated into type of nucleus, but there were 64 (87.7 percent) of the scales which had the ocean type and nine (12.3 percent) which had the stream type of early growth.

In the summer of 1947 and 1948 more observations were made. Samples were taken at Astoria and Newport in 1947 and at Astoria, Newport, and Coos Bay during 1948. There were 534 length-frequency measurements and 301 scale samples taken during July, August, and September of 1947, and 8,008 length-frequencies taken during 1948. The scale samples for 1948 have only been partially analyzed.

Due to the great difference in sizes of chinooks in the different areas and seasons, and the fact that sampling is not proportional to the catch, it is necessary to weigh the sampling by the number

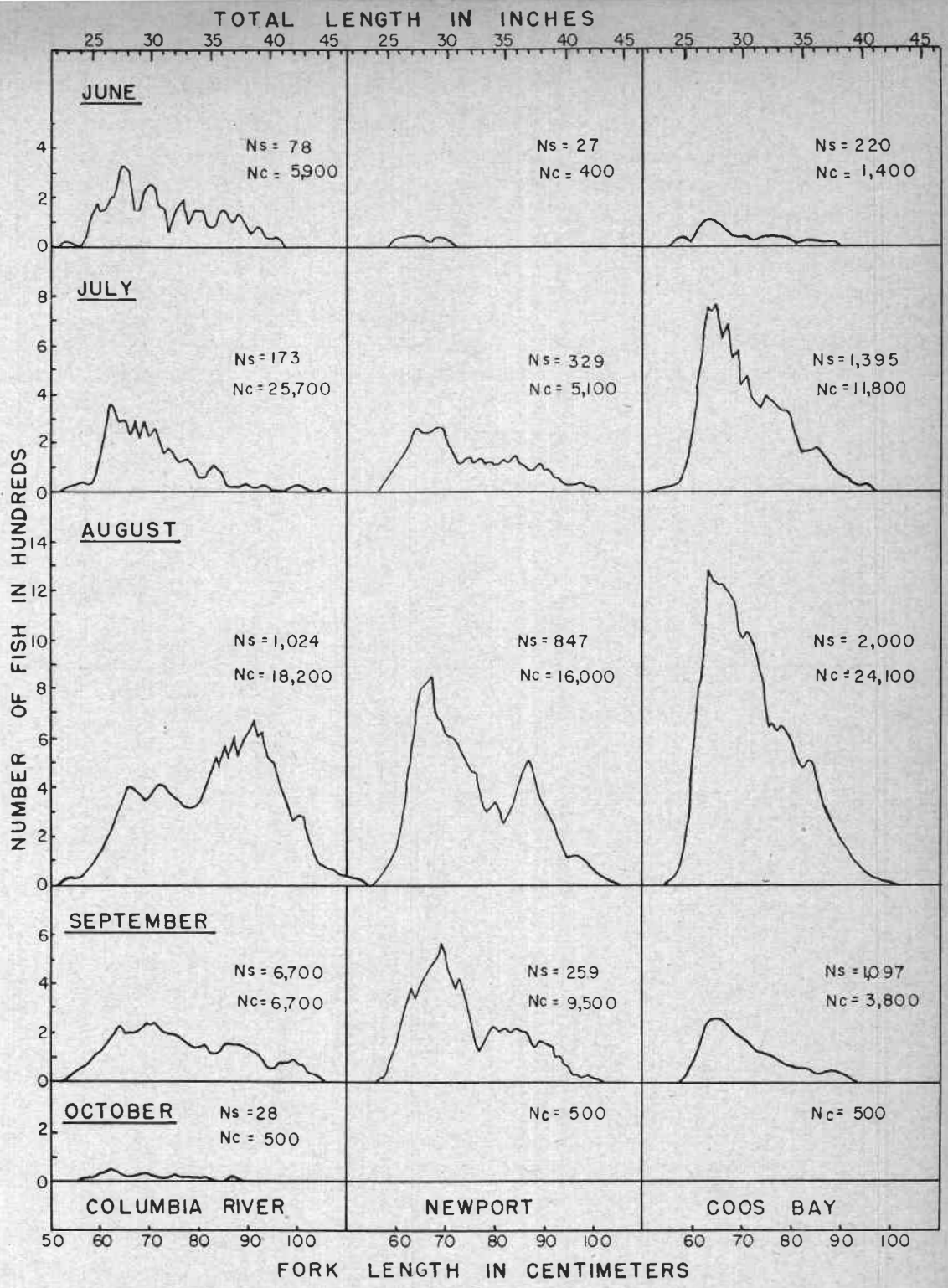

FIGURE 14. Length-frequency of the Oregon and Columbia River troll Chinook Salmon catch in 1948, by area and month.

of fish landed at each port each month in order to get a true picture of the length composition. This has been done for the 1947 and 1948 data. The small sample for 1947 did not warrant breaking down into area or month, but this was done for 1948. Figure 14 shows the variations in the size of the fish and their abundance in the different areas through the 1947 and 1948 season. There seems

to be two dominant size groups present. The Columbia River fishery was characterized by mostly small fish until August when a larger group appeared. Off Newport were found both small and large fish all season with the small fish having a slight majority, while the Coos Bay catch contained a very large number of small fish, and relatively few large ones.

In Figure 15 is shown a comparison of the length-frequencies for 1947 and 1948. Despite the small sample in 1947, it is obvious that there is a considerable difference in the length-composition (and therefore age composition) of the catch between the two years. In 1947 the large mode of fish was at about 74 centimeters, while in 1948 it was at 65 centimeters or just over the legal size limit of 27 inches total length (63.5 centimeters fork length).

The analysis of the scale samples for 1947 has been completed; it appears upon examination of the length-frequency graphs (Figures 12 and 15) and the bar graph showing the proportion of ages at each length for 1947 (Figure 16) that there would be more fish of the 3+ age group present in 1947 than in 1946. Upon calculating the age composition this proved to be the case. The scales were separated as to nucleus, and the percentage age composition of each group is as follows:

Ocean nucleus:		Stream nucleus:	
1+—	1.8 percent	2+—	7.4 percent
2+—	33.7 percent	3+—	12.2 percent
3+—	32.5 percent	4+—	8.3 percent
4+—	3.6 percent	5+—	0.5 percent
	71.6 percent		28.4 percent

The percentage with stream nuclei (28.4 percent) was slightly higher than the 22 percent found by Rich (1925).

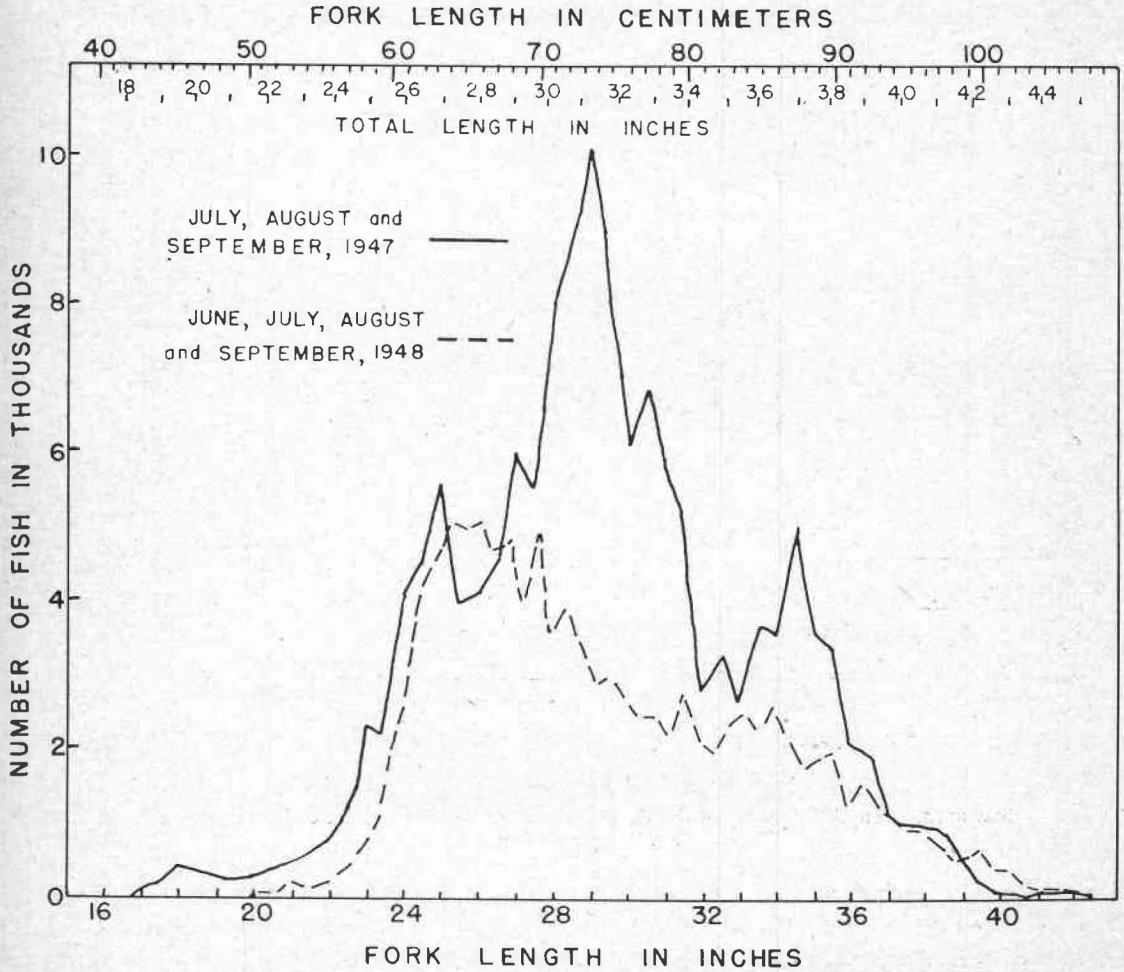

FIGURE 15. Length-frequency of the Oregon and Columbia River troll Chinook Salmon catch for 1947 and 1948.

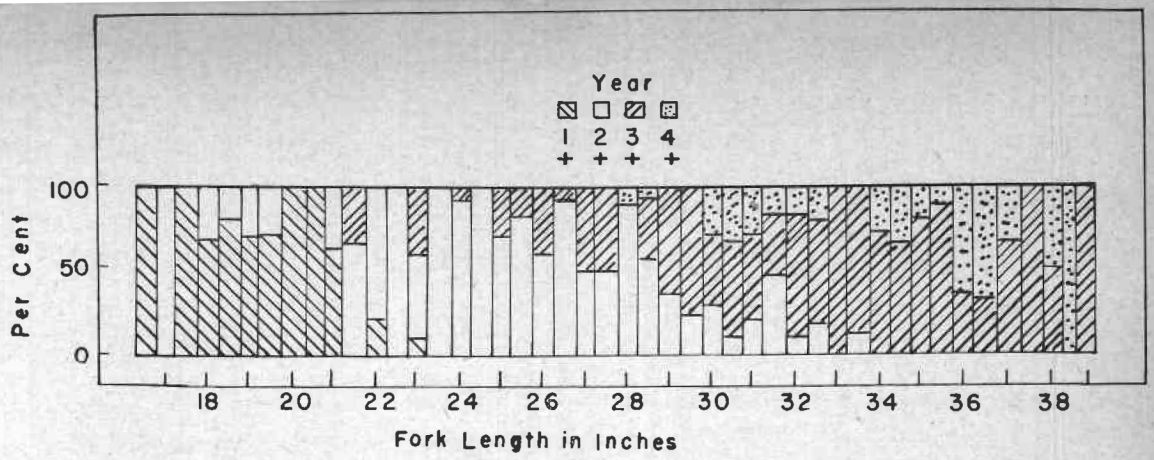

FIGURE 16. The percentage age composition for each half-inch of length for troll-caught Chinook Salmon in 1947.

Although the age analysis of the 1948 catch has not been completed, a comparison of the 1948 length-frequency graph (Figure 15) with the bar graphs of the age composition for each length of the previous two years (Figures 13 and 16) indicates that in 1948 the 2+ class again becomes dominant.

Figure 17 is a series of bar graphs showing the age composition from Rich's (1925) data of 1919 and the 1946 and 1947 Oregon experiments. In 1919, only fish caught off the Columbia River were analyzed, while the 1946 data consisted of a small sample from off the Umpqua River. In 1947 observations were made at Astoria and Newport, but very few Coos Bay fish were included, which have been found to average smaller than in the other areas. For these reasons the graphs are not strictly comparable, but it is believed that they show the general trends of age composition of chinook salmon off the Oregon coast. The preponderance of 2+ fish in 1919 and 1946 is obvious, while in 1947 there was more of the 3+ group present. A situation similar to 1919 and 1946 is expected for 1948, although with fewer of the 1+ group available to the fishery due to the 27 inch size limit. Even with a size limit of only 20 inches, the number of 1+ fish entering the catch during 1946 and 1947 was relatively small.

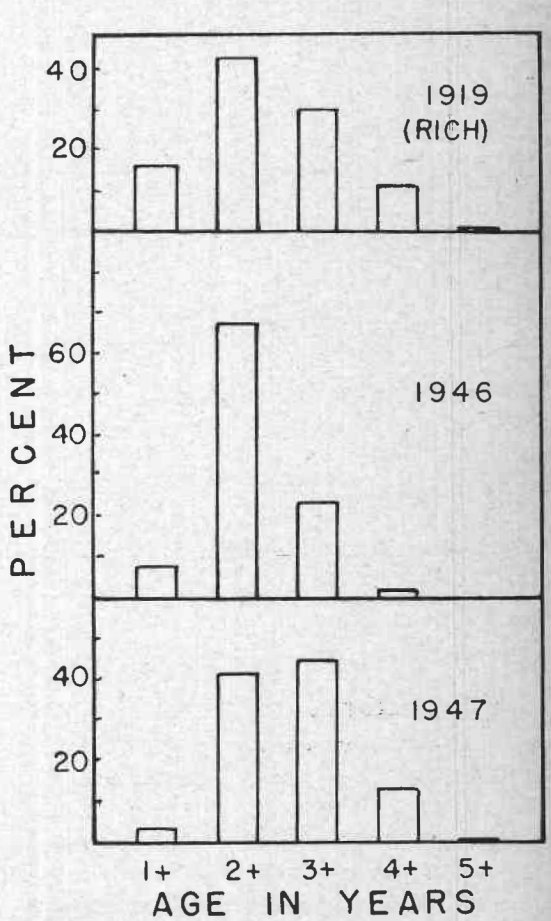

FIGURE 17. Age composition of troll-caught Chinook Salmon sampled in 1919, 1946 and 1947.

These observations on the age composition of the chinook catch are of a preliminary nature. Much more complete observations were made during the summer of 1948, which are now being analyzed, and during 1949 and 1950, scale samples and length-frequencies were taken through the entire troll season from March to November.

The troll chinook catch probably contains fish from every major stream on the Pacific Coast as well as hatchery-reared fish, and one can hardly imagine the variation that occurs in the early life history and growth patterns of their scales. The age and growth of troll caught chinook salmon

is a very complicated problem and will require a great deal more study before the results may be accepted without considerable qualification.

Growth of Chinook Salmon in the Sea

The growth rate is being determined from the analyses of the scales. As would be expected from their complicated life history, there is a great overlap of the year classes, and for that reason they are separated as to the type of first year growth. Figure 18 shows the growth curves for the fish remaining only a short time in fresh water and also for those that remained in fresh water for an entire year. As would be expected, the fish which went down to the sea during their first year average a larger size for the same age than those which stayed in the stream a year. Due to the apparent differences in the growth rate between the years, several more years of data are required before an average growth curve can be determined.

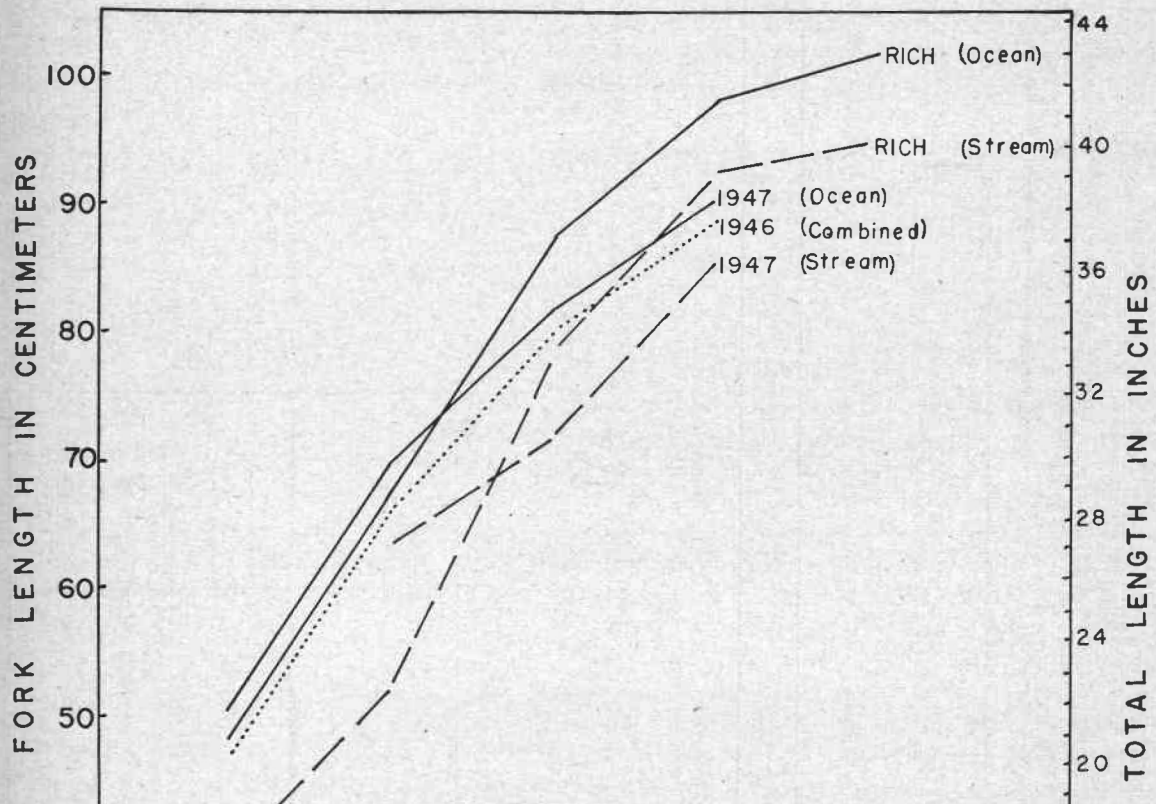

FIGURE 18. Average length at each age of troll-caught Chinook Salmon for 1919, 1946, and 1947.

Average Weight of Troll Caught Chinook Salmon

The average weight of the salmon is easily secured by counting the fish as they are unloaded from the boats and then securing the weight of the load. These data are primarily used for converting the catch statistics, which are in pounds, into numbers of fish, but they also show some of the variations in size of the chinooks during the season and in the different areas.

In 1947 samples were taken at Astoria and Newport, Astoria representing fish taken off the Columbia River and Newport representing the fish taken in the coastal areas. The average weights of all fish checked have been combined by month and are shown in Figure 19. Since the graph does not indicate the number of fish sampled, attention is drawn to the fact that only one day samples

were taken in April and May. June samples were small. In 1948 sampling began in June and continued through October (Fig. 19). In 1949 (Fig. 19) sampling was begun in April and continued through October.

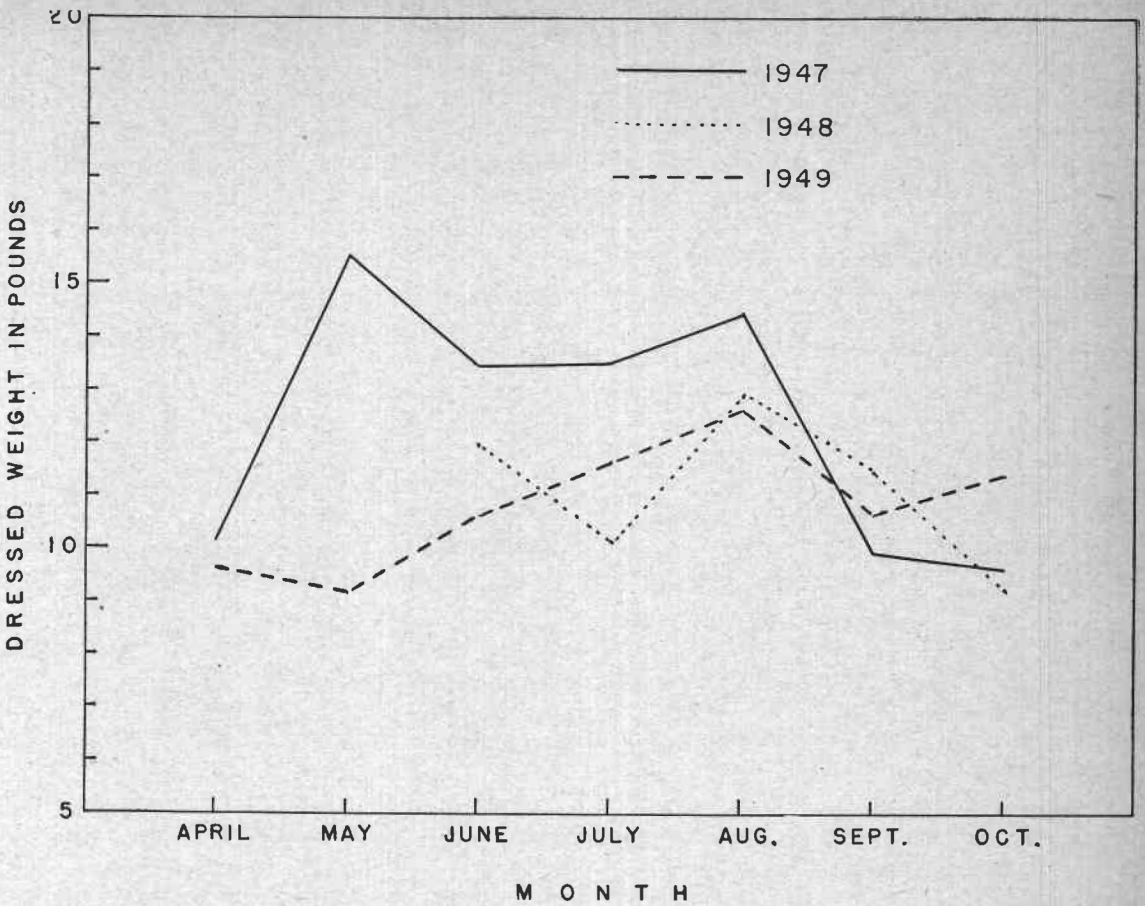

FIGURE 19. The average weight of troll-caught Chinook Salmon in 1947, 1948, and 1949, by month, Oregon.

The data show in general that there is usually a peak in average weight early in the season, but varying considerably as to month of occurrence and ranging from 10 to 15 pounds. Following this early and rather inconsistent peak in average weights, there follows, apparently, a drop followed in every case by a definite and consistent rise in August. After August when the big fall chinook run enters the Columbia River the average weight drops with the departure of the mature fish.

THE OCEAN SPORT FISHERY OF OREGON

Another factor in the ocean catch of salmon is the ocean sport fishery. A few sportsmen have fished for salmon in the ocean for many years, but since World War II the sport has expanded and become highly commercialized. The fishery is prosecuted mainly from the port of Depoe Bay, Oregon. This small picturesque bay on the central Oregon coast harbors a large fleet of sport and commercial trollers. The fishery has branched out in recent years until nearly every port on the Oregon coast now has a few boats which take parties sport fishing on the ocean. The Depoe Bay and Newport fleet consists of large luxurious yachts, but in the other places smaller cruisers are used.

The mainstay of this fishery is the silver salmon, but in the absence of salmon, the boats seek ling cod, rock fish, and halibut. Occasional trips are made for albacore when they approach the shore. Chinook salmon usually swim too deep to be taken in any numbers by the sport gear. In 1949 most of the salmon were caught during August with July and September furnishing some fish.

A preliminary survey of this fishery was made in 1949 to determine the number of fish caught. Log sheets were supplied the skippers of the party boats, in which they recorded the number of fish caught each day.

There were 14 boats engaged in this fishery out of Depoe Bay and Newport. Good records were obtained from 11 of them. These 11 boats caught 363 chinooks and 4,423 silvers during the season, for an average of 33 chinooks and 402 silvers per boat. The three boats without records were presumed to have caught this average number also. The total ocean sport catch in the Depoe Bay-Newport area was calculated to be about 500 chinooks and 6,000 silvers.

Seven small boats operated out of Coos Bay on a part-time charter basis, and they caught 36 chinooks and 517 silvers. Four boats fished out of Winchester Bay, three out of Tillamook Bay, one out of the Siuslaw River and there were possibly several more unnoticed. No data were obtained on their catch, but it was estimated that they landed about the same number of salmon as the Coos Bay fleets or around 50 chinooks and 600 silvers.

Five or six surplus navy DUKW operated through the surf at Pacific City, Rockaway, and Seaside. While these were used primarily as excursion boats, they also took out fishing parties, and at times these vessels caught considerable numbers of salmon. Although their exact catch is not known, it was comparable with or slightly greater than the seven boats at Coos Bay, and it may be roughly estimated in the magnitude of 100 chinooks and 1,000 silvers.

On exceptionally calm days it was possible to take small outboard motor boats out of almost any of the bays along the coast. The catch of these small boats was believed to be of minor importance, compared with the other fisheries.

Frequently immature salmon enter the various bays on feeding migrations, and are subject to a skiff fishery. These migrations seem to be rather sporadic and entirely absent in some years. Large numbers of feeding fish were found in Coos Bay, Winchester Bay, and possibly others in 1949. Mathisen (1950) gives the 1949 summer sport catch at Winchester Bay as 1,200 chinook and 3,800 silver salmon. He was of the opinion that the bulk of the salmon entering the Umpqua estuary in June, July, and early August were feeding and moving along the coast en route to their spawning destinations in other streams. He stated that chinooks marked in the Columbia River have been caught in Winchester Bay in July.

Since this is a bay fishery, it is not included in the ocean catch, although the stocks of fish are probably the same as the ocean fishery takes.

A considerable ocean sport fishery takes place off the Columbia River, but this is rather difficult to evaluate. During the August and September salmon run into the Columbia River, large numbers of cruisers and chartered commercial fishing boats fish in the Columbia River and just outside in the ocean. While fishing primarily for the large chinook salmon, they also take numbers of immature chinook and feeding silver salmon. It would be difficult to tell what percentage of the lower Columbia River sport catch is actually composed of ocean fish, since the same boats fish both inside and outside the river.

Adding together these various estimates, the general magnitude of 700 chinooks and 9,000 silvers were taken by the ocean sport catch on the Oregon coast in 1949. Converted to pounds, on a basis of 13.0 pounds as the average round weight of troll-caught chinooks and 7.8 pounds for silvers, this gives 9,000 pounds of chinook salmon and 70,000 pounds of silver salmon. This estimate does not include the bay fisheries or the outside Columbia River fishery. The 1949 commercial troll season was poor for silver salmon and below average for chinook salmon. In an average or good year, the sport catch would be much greater than this.

At the present time the ocean sport fishery is not of serious consequence compared with the commercial troll fishery, but it is expanding rapidly and promises to become an increasingly important component of the ocean salmon catch in the future.

SUMMARY

1. The Oregon troll salmon fishery developed rapidly prior to World War I to reach a peak of between one and three thousand boats fishing off the mouth of the Columbia River during 1919. The fishery later expanded to the other coastal areas. There has been a decrease in the number of boats fishing, but a great increase in their efficiency. The development of the tuna fishery resulted in the larger trollers fishing for tuna during the late summer and concentrating on salmon during the spring and early summer. There are about 500 trollers which make Oregon ports their base

of operations at the present time. Since 1940 the Oregon troll fishery has landed about 3,000,000 pounds of chinook and silver salmon per year. The troll fishery was practically unregulated until 1948, at which time, preliminary regulations were imposed.

2. Preliminary troll regulations which were imposed since 1948 and altered somewhat in 1949 include a 26 inch minimum size limit and a closed season from November 1 to March 15 on chinook salmon. A closed season for silver salmon extends from November 1 to June 15 to prevent the landing of small silvers during the late spring.

3. This report covers in part the tagging and biological data gathered by the staff of the Oregon Fish Commission during 1946, 1947, 1948 and 1949.

4. There were 506 silvers tagged off Oregon in 1948 and 1949, and 29 (5.7 percent) were recovered. By far the greater percentage were recovered north of their tagging location, indicating a northward migration of silvers in their third and last year to their spawning streams.

5. The recovery of marked silver salmon in the ocean, confirms the findings of the tagging in that early in the season (June) the marked fish were found south of their home streams, and as the season advanced they moved north until during September they were grouped around the mouths of the rivers.

6. The length-weight relationship of troll-caught silver salmon was found to be an exponential type of relationship, and the equation for 1947 is $W=0.23215 \times 1.0535^{L}$; that for 1948 is $W=0.27952 \times 1.04949^{L}$.

7. The commercial catch of silver salmon is composed largely of individuals in their third year. There seems to be a considerable difference between the growth rates of different years, but the silvers show an average increase in mean weight from about 4.5 pounds on June first to about eight pounds by November first, dressed weight. They showed an increase in modal length in 1948 from 25.2 inches (total length) in June to 30.4 inches (total length) in November.

8. There were 221 chinook salmon tagged in 1948 and 1949 and eleven recoveries were made. No consistent migration pattern is apparent, but it is apparent that the chinook move both north and south of their natal streams and probably migrate farther than do the silver salmon.

9. The length-weight relationship of the chinook salmon was found to conform to the usual parabolic relationship, $W=AL^{b}$. The equation for 1947 was $W=0.000013126\ L^{3.17008}$ and for 1948, $W=0.000009256\ L^{3.24142}$.

10. The age and growth of the troll caught chinook salmon was studied. The 2+ group was the dominant year class in the catch of 1919, 1946, and probably 1948, but in 1947 there was slightly more of the 3+ group. The 3+ group was next in abundance in 1919 and 1946, with the 1+ group age class comprising a relatively small part of the catch. There is a considerable variation in the sizes and ages of chinooks found in the different areas at different times, and also between years.

11. During April and May, trolling is concentrated off the mouth of the Columbia River. Usually there is a slight peaking in average weight in the spring, followed by a decline and a subsequent rise to a peak in August. In all cases average weight dropped appreciably after August.

12. The ocean sport fishery operates mainly out of Depoe Bay and Newport, with smaller fleets out of nearly every port on the Oregon Coast. The estimated ocean sport catch in 1949 was 700 chinooks (9,000 pounds) and 9,000 silvers (70,000 pounds).

ACKNOWLEDGMENTS

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